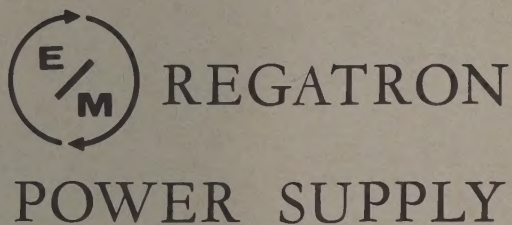


INSTRUCTION MANUAL



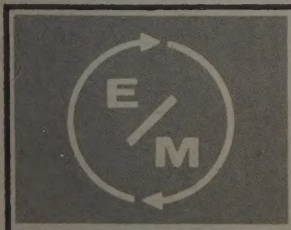
MODEL 0612AL

SERIAL No. 2342

MP MASTER



MA27878



ELECTRONIC MEASUREMENTS

A Division of THE ROWAN CONTROLLER COMPANY
EATONTOWN • NEW JERSEY

TELEPHONE: (201) 542-0300

TWX: (201) 542-2273

CABLE: ELMEASCO

Warranty

Electronic Measurements instruments are guaranteed to be free from defects in material and workmanship for one year from the date of purchase (except for tubes, fuses and batteries). Our liability under this warranty is limited to repairs and adjustments or replacements of defective parts or instruments when the fault is a direct result of defective materials or workmanship in the manufacture of the apparatus. This warranty covers service for the first year, except for transportation to and from the factory. If any fault develops in the equipment, the following steps should be taken:

1. Notify ELECTRONIC MEASUREMENTS. Give full particulars of the difficulty and include the serial number of instrument in question. On receipt of this information, we will give you service information or shipping instructions.
2. On receipt of shipping instructions, forward the apparatus to us, prepaid, and we will make repairs and adjustments immediately at the factory.
3. If the fault has been caused by misuse, or abnormal conditions of operation, as disclosed by our examination, repairs will be billed at cost. In this case, an estimate of the cost will be submitted before work is started.

ELECTRICAL STANDARDS

All company primary standards are either certified directly or are traceable to certification by the National Bureau of Standards.

CLAIM FOR DAMAGE IN SHIPMENT

This instrument received comprehensive visual and electrical inspections before shipment. Immediately upon receipt from the carrier, and before operation, this instrument should be inspected visually for damage caused in shipment. If such inspection reveals internal or external damage in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. When referring to this instrument, always include the model and serial numbers.

March 1964

INSTRUCTION MANUAL

REGATRON[®] CONSTANT-CURRENT PROGRAMMABLE POWER SUPPLY

MODEL C612A2

SERIAL NO. _____



**ELECTRONIC
MEASUREMENTS**

EATONTOWN • NEW JERSEY

TELEPHONE: (201) 542-0300

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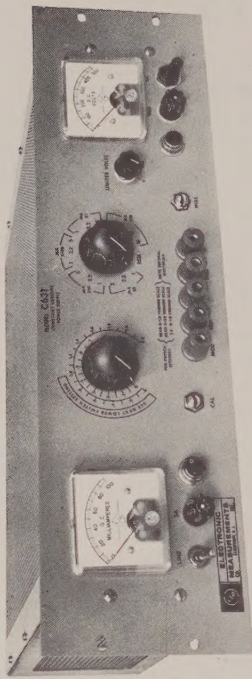
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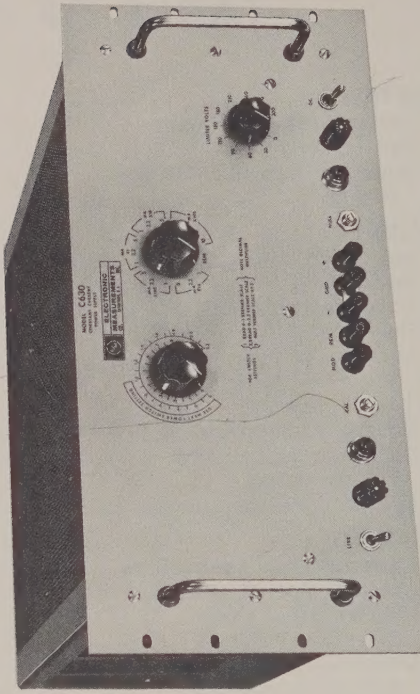
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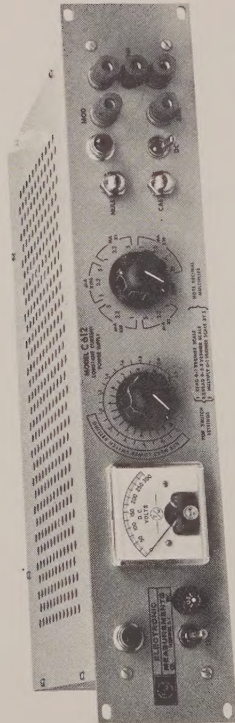
PARTS LIST AND SCHEMATIC DIAGRAM Insert



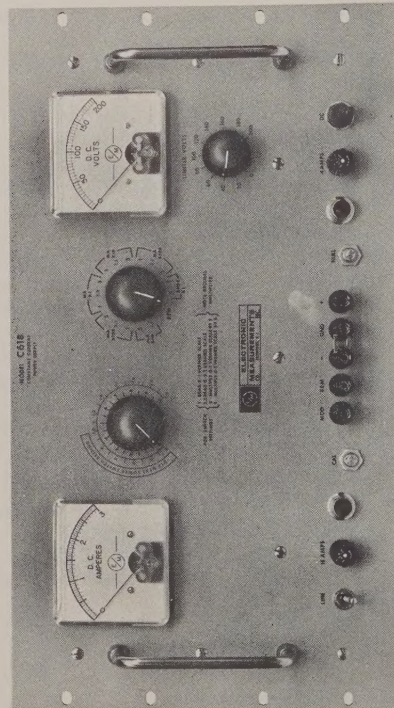
Model C631



Model C630



Model C612



Model C618

Figure 1-1. Typical Regatron Constant-Current Programmable Power Supplies

CHECKING OUT AND TROUBLE-SHOOTING SERIES C600

CONSTANT-CURRENT POWER SUPPLIES

This write-up is primarily for the purpose of E/M final electrical inspectors. It is designed to get a constant-current unit operating that has never been operating before. However, it can be used as a guide for repairing constant-current units that were previously operational.

A. PRELIMINARY EXAMINATION

1. Examine the unit for obvious defects; that is, wires not soldered, components broken or improperly assembled, and so on.
2. Remove all removable tubes and transistors, turn LIMITER control potentiometer to maximum, remove diode from around 2N2191 transistor and remove diode from emitter of 2N2191 and cathode of 12AY7. (Unsoldering one end of diodes is adequate.) On C638A's remove one AC wire from primary of H.V. transformer.
3. Plug AC line into an AC power source that is controlled by a variac that is set for zero volts.
4. Turn variac to 5 volts AC.
5. Turn AC and DC switches on.
6. With a multimeter, check voltages across all electrolytic capacitors to make sure that they are wired properly. For those units that have a TDR, it will be necessary to actuate the TDR manually to check the voltages across the screen voltage capacitor and the main power capacitor. Care must be exercised with high voltage units, as dangerous voltages can be developed with this very low line voltage. Make necessary corrections and proceed to Step 7.
7. Turn variac to 125 volts AC. Units with TDR must be allowed time for TDR to actuate.
8. Measure the voltage across all electrolytic capacitors for:
 - a) Proper voltage.
 - b) To make sure that none of the electrolytics are operating above rating.

NOTE: If unit has a chopper, remove chopper module and short together pins 5 and 6 of socket.

B. FILAMENT REGULATOR

(See NOTE at end of Section B)

1. Plug the 2N1372 transistors into the filament regulator section.
2. Plug in the 12AY7 error detector (input) tube.
3. Put a DC voltmeter across the filament regulator. This would be from collector of EM 101, diamond-shaped transistor, to pin 9 of the 12AY7 (see previous step).

4. Turn AC of unit on and set variac to 105 volts AC. DC voltage should be about 10 volts (if not, change DC voltmeter from pin 9 of 12AY7 to pin 4 or 5 of 12AY7).

5. Turn variac to 125 volts AC. Voltage should rise to about 12.5 DC.

6. If voltage is different, check wiring from DC connections to the filter of the filament regulator of the DC voltage. If necessary, make corrections and proceed to Step 7.

7. Put DC voltmeter across filament of 12AY7. This would be pin 9 and 4 or 5 of the 12AY7.

8. Adjust voltage for 5.8 to 6.0 volts DC. If adjustment can't be made, proceed as follows:

- a) Remove one end of the 30 ohm resistor in parallel with the EM101 transistor.
- b) Remove two 2N1372 transistors. The filament voltage should fall to zero. If it doesn't check the filament regulator section for proper assembly, and the EM101 for short.
- c) Replace the first driver transistor. The filament voltage should rise to maximum input voltage. If not, check the first driver transistor.
- d) Replace second 2N1372. After making necessary corrections and adjustments, proceed to Step 9.

9. Vary line voltage from 105 to 125. Regulator voltage should not vary more than 100 millivolts.

10. Turn constant-current unit off.

NOTE: The EM101 is the series regulating transistor. It is a PNP germanium diamond-shaped transistor. In the C612's and C624's the series regulator has been changed to an NPN, silicon, medium power transistor. The 2N1372 is a PNP, germanium, signal transistor. In the C612's and C624's the signal transistors are NPN, silicon. Similar transistors may be substituted.

C. POSITIVE AND NEGATIVE SUPPLY VOLTAGES

If unit has a chopper stabilizer, remove chopper module and place short between pin 5 and pin 6 of chopper socket.

1. Plug in all of the gas regulator tubes. For the C612 and C624 there are three....two OA2's and one 85A2. For all others there are five. Two OA2's, two OB2's and one 85A2.

2. Turn AC on.

3. Check to make sure that all of the VR tubes are glowing. Vary the line voltage from 100 volts AC to 130 volts AC and check to make sure that none of the VR tubes extinguish.

4. If any tubes are not glowing, one of the following is probably the reason:

- a) Glow tube has an extra high starting voltage. Check voltage drop across this tube. If higher than normal operating voltage, replace the glow tube.
- b) There could be a wiring error such that a glow tube is partially or completely shorted. The voltage across the glow tube will be lower than normal operating voltage. This extra current drain must be found.

- c) The pc socket is not properly soldered. Check voltage across the tube from copper side of pc board. Check voltage across tube by removing tube and putting probe into the pin holes. If the voltages do not match, chances are the pc socket is not soldered in properly.
- d) The connecting resistor may be open, or wrong value.
- 5. Turn AC off and make necessary corrections.

D. PRELIMINARY BALANCE OF AMPLIFIER

- 1. Turn range switch to REM position. If unit is fully programmable, this step is not necessary.
- 2. Connect jumper between positive output terminal and REM terminal.
- 3. Connect jumper between negative output terminal and MOD terminal.
- 4. Plug in the two 2N2191 amplifier transistors.
- 5. Connect a DC voltmeter between input grid of the next stage (this would be pin 1 of the 6AU6 on all units but the C638, and on the C638 it is pin 4 of the 6842) and the remote terminal. This is accomplished by putting a probe into the proper location in the tube socket and the other probe of the voltmeter on the REM terminal.
- 6. Turn AC on and DC switch on.
- 7. After warm-up, rotate the NULL potentiometer from maximum to minimum. The voltage (see Step 5) should vary from about -70 volts DC to about -100 volts DC. If it doesn't, there are problems in the input stage and the transistor amplifier stage. Make the following checks:
 - a) Check to see that the sockets of these components are soldered in properly. This can be done by removing the 12AY7 tube and the two 2N2191 transistors, and making a point to point check between socket and pc copper.
 - b) Wiring from the NULL potentiometer to the pc board is not correct.
 - c) Wiring from the grids of the 12AY7 to the MOD and negative output terminal is not correct.
 - d) The one or both of the 2N2191 transistors are defective.
 - e) The 830K and/or 330K collector resistors of the 2N2191 transistors are not of proper value.
 - f) One or more of the 22K resistors in the plates and emitters of the 12AY7 and the two 2N2191 transistors are not correct.

Turn AC off and make necessary corrections and proceed to Step 8.

- 8. Plug in the next amplifier tube (6AU6 in all units but C638. C638 uses a 6842.)
- 9. Connect the DC voltmeter between the REM terminal and plate of 6AU6 (6842 in C638.)
- 10. Turn AC on and wait for warmup.
- 11. Vary NULL potentiometer from maximum to minimum. Voltmeter should vary from about -40 volts DC to +150 volts DC. This variation should occur over a very small range of NULL potentiometer rotation.
- 12. If this does not happen there is trouble in the 6AU6 (6842

in C638) amplifier stage. This could be one of the following:

- a) Tube socket not properly soldered.
- b) Wrong plate resistor.
- c) Wrong screen grid divider resistors.

Turn AC off and make necessary corrections and proceed to Step 13.

13. For those units having a cathode follower between the final amplifier and the series dropping tubes, plug the 12AX7 cathode follower in.

14. Connect a DC voltmeter between REM terminal and the cathode of the 12AX7 cathode follower.

15. Turn AC on and wait for warmup.

16. Rotate NULL potentiometer from maximum to minimum. Voltage should vary from about -40 volts DC to about +150 volts DC. This variation should occur over a very short rotation of the NULL potentiometer.

17. If this does not happen, there is trouble in the 12AX7 cathode follower. This could be one of the following:

- a) Wiring error....check out all associated wiring.
- b) Wrong components.
- c) Bad 12AX7 tube.

Turn AC off, make necessary corrections and proceed to Step 18.

18. Remove jumper from positive output to REM terminal.

19. Plug in one of the series tubes and connect wire to H. V. transformer.

20. If unit has no meters, put voltmeters between positive output terminal and REM terminal.

21. Turn AC on and wait for unit to warm up (on C638 set input voltage control to about 300.)

22. Rotate NULL potentiometer from maximum to minimum. Output voltage should vary from 0 or slightly negative to the maximum capability of the unit. This should occur over a very narrow range of NULL potentiometer rotation.

23. If unit does not operate in this manner, trouble is in series deck and wiring. It could be one of the following:

- a) Bad DC fuse.
- b) Bad series tube.
- c) Improper wiring.
- d) Wrong component
- e) Poor solder joints.

Turn AC off, make necessary corrections and proceed to Step 24.

24. Put in all series tubes and repeat Steps 18 through 23. Set NULL potentiometer so that voltmeter is somewhere between 0 and maximum. The voltmeter will tend to drift considerably. Turn AC and DC off, make necessary corrections, remove all jumpers from output terminals and proceed to the next section.

E. PRE-TEST

- 1. Set unit for 10 ma of operation.
- 2. Put jumper between positive and negative output terminals.
- 3. Put high impedance voltmeter between negative output terminal and MOD terminal.

4. Turn AC on and wait for warmup.
5. Turn DC on and adjust NULL control for zero on high impedance voltmeter.
6. Turn DC off.
7. Turn vernier control to maximum.
8. Place voltage checking device (high impedance 1/2% accuracy equipment) between REM terminal and MOD terminal.
9. Adjust CAL control for 5.0 volts DC.
10. Replace jumper from positive and negative terminals with an ammeter. A multimeter should be adequate.
11. Turn DC on and check all current ranges for correct values of current. This is to check out the range switch for proper construction and location of parts. The unit is now ready for final checks.
12. Turn DC switch off. Turn AC switch off.

F. VOLTAGE LIMITER

1. Check wiring of limiter, particularly LIMITER potentiometer and CAL potentiometer.
 2. Plug in limiter components, two transistors of type 2N398 or 12AX7 and one 2N398.
 3. Remove all loads from output terminals of unit.
 4. Turn AC of unit on and wait for warmup.
 5. Turn DC on.
 6. Voltage should go to maximum.
 7. Slowly turn LIMITER control towards zero.
 8. Voltage should start dropping off by the time potentiometer has reached 90 degrees of rotation.
 9. Rotate potentiometer 2/3 of the way down. If voltage has not dropped, something is wrong with the limiter. If there are problems, it is probably one of the following:
 - a) Reference resistor not installed.
 - b) Diode switch between 6 AU6 grid and collector of limiter transistor is not operating.
 - c) Limiter transistor is bad.
- Turn unit off and make necessary corrections and recheck, and proceed to Step 10.
10. After limiter is operating for DC, check for oscillations.
 11. It may be necessary to change the capacitor across the collector resistor of the limiter transistor, or
 12. Put in a capacitor between positive output and arm of control potentiometer, or
 13. Put in a capacitor between positive output and collector of transistor that drives 6AU6.
 14. After unit is operating properly turn DC and AC switches off.

G. CHOPPER-STABILIZER

1. Remove short from pins 5 and 6 of chopper socket.
2. Check wiring to make sure the 120K resistor and extra 20 microfarad, 25 volt capacitor is in place.
3. Plug in chopper module. Plug into module the 12AX7 (or

12AY7) tube and mechanical chopper.

4. Turn AC on and wait for warmup.
5. Place ammeter between positive and negative terminals.
6. Set unit for 10 ma operation.
7. Place a high impedance voltmeter between negative output and arm of vernier.
8. Turn DC on and vernier to maximum.
9. Wait a few minutes until chopper has settled and check current. It should be near zero.
10. Check high impedance voltmeter. It should be near zero.
11. Rotate NULL potentiometer back and forth. High impedance voltmeter should show abrupt change but should return to within a few mv of original position.
12. The only probable things that might be wrong are:
 - a) A bad mechanical chopper.
 - b) A bad 12AX7 tube.
 - c) Bad filter capacitor in chopper module.
 - d) Improper wiring.

After unit has been checked, remove chopper module, replace short between pins 5 and 6 of chopper socket, and reset NULL for zero on high impedance voltmeter, and then remove the short and replace the module. The unit should always be operating with a minimum output from the chopper.

SECTION 1

DESCRIPTION

1-1. GENERAL CHARACTERISTICS.

This Regatron[®] Constant-Current Power Supply (see Figure 1-1) provides a highly regulated dc output in 16 ranges. Within a selected range, the output is continuously variable from zero to the limit of that range by a front panel control. The output can also be programmed* (remotely controlled) by the use of an external resistor. A panel voltage limiter control (standard, except for C612 and C624) permits control of maximum voltage available for application to the load range is from zero volts to maximum compliance shown in Figure 1-2. The power supply can be mounted in a standard 19-inch rack, or it can be panel-mounted on rubber feet. On the front panel are a Range Selector switch, a Range Sweep control, current NULL and CAL adjustments, a LIMITER VOLTS control (optional for C612 and C624), a D. C. VOLTS meter, a LINE switch, a DC switch, associated indicator lamps, and FUSE tags. External connections can be made at universal binding posts on the front panel, or at a barrier-type terminal strip on the rear of the unit. A swinging link is provided to permit selection of positive or negative ground or floating output.

When specified, the power supply is supplied with chopper stabilization, which provides a constant-current output of exceptional stability. The unit is easily adapted for constant-voltage output by a simple external conversion.

Detailed technical data are given in the Table of Specifications (see Figure 1-3).

1-2. APPLICATIONS.

This Regatron power supply can be used in any application where a regulated, constant-current, programmable dc power source of the specified ratings (see Figure 1-2) is a requisite. Typical applications follow:

Measurement of peak inverse voltage of solid-state junctions.

Measurement of transistor leakage.

Testing reference diodes for voltage ratings and dynamic impedance.

Providing a dc potential source for transistorized circuits.

Ampere-turn control in the generation of magnetic fields.

Relay testing.

Use as a power source for dc gyrometers and torquers that require precise rpm control.

Checking operating voltage of gas tubes.

Calibrating dc ammeters.

Producing arcs in gaseous breakdown devices.

Forming capacitors.

1-3. STANDARD VERSIONS OF POWER SUPPLY.

Several standard versions of this Regatron Constant-Current Power Supply are available: metered or un-metered; with or without front panel controls; with rear, or front and rear, terminations; and with or without chopper stabilizer. If the LIMITER VOLTS control is supplied with the C612 or C624, either the dc voltmeter or the front terminals must be eliminated.

BASIC MODEL NO.	C612A	C631	C638	C624A	C632	C636	C629	C633	C620	C621	C613	C614	C628	C630	C625	C626	C615	C618
CONSTANT-CURRENT OUTPUT RANGES: Sixteen ranges, zero to range max, available in each range with vernier sweep.	1 ua-100 ma	1 ua-100 ma	0.5ua-100 ma	2.2ua-220 ma	2.2ua-220 ma	2.2ua-220 ma	2.2ua-300 ma	2.2ua-300 ma	5 ua-500 ma	5 ua-500 ma	10 ua-1A	10 ua-1A	10 ua-1A	10 ua-1A	22 ua-2A	22 ua-2A	22 ua-3A	22 ua-3A
VOLTAGE COMPLIANCE At min. range setting At max. current output	260 100	420 300	2200 1500	260 100	420 300	730 600	210 150	420 300	120 50	170 100	120 50	170 100	220 150	280 200	150 75	190 100	120 50	170 100
VOLTAGE LIMITING: zero to compliance max.	OPT.	STD.	STD.	OPT.	STD.	STD.	STD.	STD.	STD.	STD.	STD.	STD.	STD.	STD.	STD.	STD.	STD.	STD.
PROGRAMMING CONSTANT: microamperes per ma of output	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
CURRENT REGULATION	LINE LOAD																	
RIPPLE & NOISE: 0.04% rms of range setting plus...	0.5ua 0.1ua	0.5ua 0.1ua		0.7ua 0.15ua	0.5ua 0.1ua	1 ua 0.2ua	1 ua 0.2ua	2 ua 0.2ua	2 ua 0.2ua	2 ua 0.2ua	2 ua 0.2ua	2 ua 0.2ua	4 ua 0.4ua	4 ua 0.4ua	8 ua 0.8ua	8 ua 0.8ua	4 ua 0.4ua	4 ua 0.4ua
(See Note)																		
STABILITY: in % of range selector setting, under fixed line, load, and temp. conditions for 8-hours after warmup																		
CHOPPER-STABILIZED STANDARD																		
TRANSIENT RESPONSE: Milliseconds required to recover within reg. limits for step change from 0 to 100 or 100 to 0 V.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OUTPUT IMPEDANCE																		
MODULATION INPUT: bandwidth constant to 5 kc, with roll-off from 5 kc to 10 kc. MOD input impedance 5000 ohms. (✓=yes)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WATTS INPUT POWER: at full load, 125V AC, 60 cps	150	245	1100	175	255	470	190	320	180	200	340	370	525	625	700	760	1000	1175
AMBIENT TEMPERATURE RANGE																		
DIMENSIONS IN INCHES	3-1/2 19 9-1/4	5-1/4 19 15	10-1/2 19 16-3/4	3-1/2 19 9-1/4	5-1/4 19 15	8-3/4 19 15	5-1/4 19 15	5-1/4 19 15	5-1/4 19 15	5-1/4 19 15	5-1/4 19 15	5-1/4 19 15	8-3/4 19 15	8-3/4 19 15	8-3/4 19 15	8-3/4 19 15	10-1/2 19 16-3/4	10-1/2 19 16-3/4
NET WEIGHT IN LBS., APPROX.	15	40	80	16	40	52	30	40	30	30	45	45	46	46	46	46	77	77

FEATURES COMMON TO ALL MODELS:

OVERLOAD PROTECTION. Input ac line and dc output line fused. Safe operation into short circuit load.

CASE GROUND POLARITY. Swinging links for positive or negative ground or floating output.

CONTROLS. Multi-range current selector and sweep vernier. Null and calibration adjustments on panel. All controls wire-wound except voltage limiter.

TERMINATIONS. Front and rear are standard. Front are insulated binding posts (BNC's on C638CH); rear are barrier-type terminal

STRIPS. Line cord is 3-conductor type.

FINISH. Smooth gray semi-gloss enamel. Class 2 per MIL-A-15090, with black and red panel markings.

MOUNTING. Units fit standard 19" racks and are equipped with rubber feet for table use.

AC INPUT POWER. All models available for either 115 volts ac input, or 220 volts ac input, 50-60 cps single-phase power. The 115-volt version is normally supplied unless 220-volt input is specified.

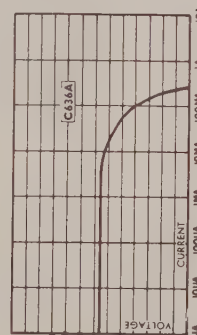
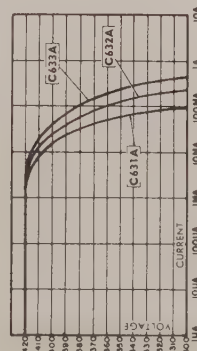
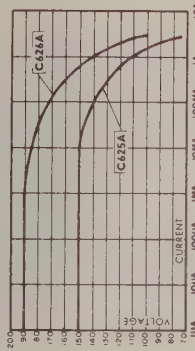
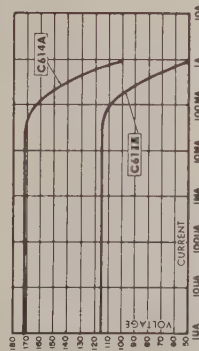
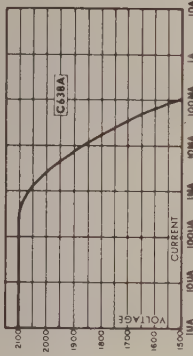
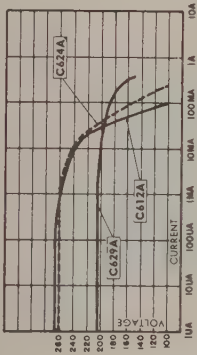
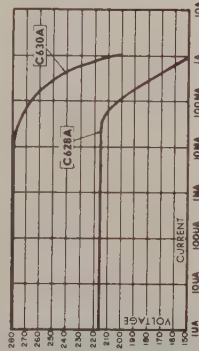
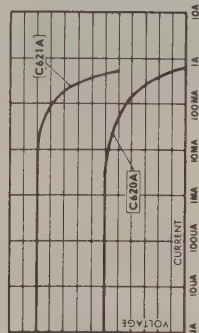
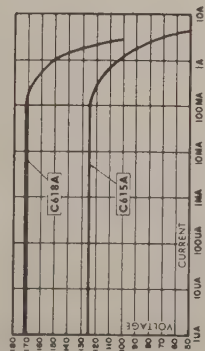
NOTE:

In floating output, ripple exceeds figure specified for positive ground according to character of load and load connections. For 220-volt input, ripple figures are doubled.

Figure 1-2. Table of Specifications (Sheet 1 of 2)

VOLTAGE COMPLIANCE CURVES

Voltage compliance, defined as the load voltage capability of a constant-current power supply, is analogous to maximum current rating for a voltage regulated unit. These graphs of voltage compliance indicate that actual compliances far exceed the nominal compliances when current output is below maximum.



INTERNAL IMPEDANCE VS. OUTPUT CURRENT at low frequency

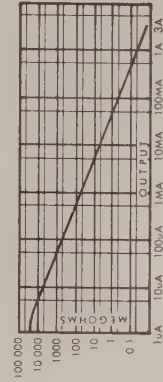


Figure 1-2. Table of Specifications (Sheet 2 of 2)

SECTION 2 OPERATION

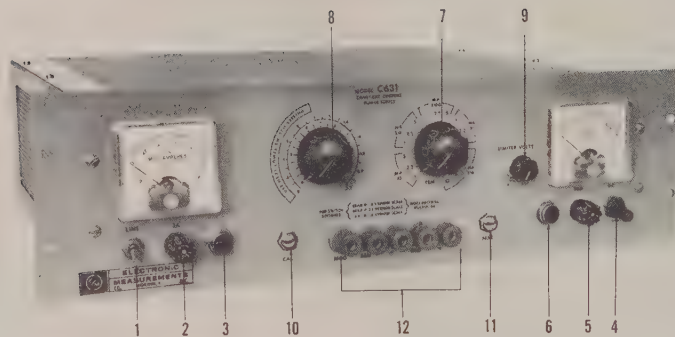


Figure 2-1. Front Panel Controls and Indicators, Typical

2-1. INSPECTION BEFORE USE.

As soon as the power supply has been unpacked, inspect it visually for signs of damage incurred during shipment. If any damage is discovered, read Claim for Damage in Shipment Instructions on Warranty printed inside the front cover of this manual, and follow procedure outlined therein. Before operating equipment for the first time, be sure all shipping blocks have been removed from inside unit. Check to see that all electron tubes and transistors are securely seated in their sockets, and operate all switches and knobs to be sure they function smoothly without binding.

2-2. INSTALLATION.

Mount power supply in a standard 19-inch rack, or place it on a table, as required, near ac input source (refer to Table of Specifications, figure 1-2). Screw holes in each side of front panel provide for securing the unit to a rack, and four rubber feet on the bottom of the unit provide for table mounting.

CAUTION

Sufficient clearance must be provided above and below power supply to insure adequate ventilation. If necessary, remove top and bottom covers to increase ventilation when ambient temperature is above normal.

2-3. CONTROLS AND INDICATORS.

The controls and indicators on the front panel are illustrated in figure 2-1 and explained in figure 2-2.

2-4. PRECAUTIONS.

Certain precautions must be observed to prevent deterioration of regulation at the load when the power supply is operated at very low currents and high load voltages, and to prevent the injection of ripple into the system because of inadequate shielding of load and output lines.

CONTROL OR INDICATOR	FUNCTION
(1) LINE switch	Used to apply ac power to power supply input.
(2) LINE fuse	Protects primary input circuit from overloads.
(3) LINE indicator	Lights when ac power is applied to unit.
(4) DC switch	Used to switch constant-current output on or off.
(5) DC fuse	Protects dc output circuit against overloads.
(6) DC indicator	Lights to indicate that constant-current output circuit is operating.
(7) Range Selector switch	Used to select one of 16 output current ranges or remote operation.
(8) Range Sweep control	Used to adjust output current to desired setting within selected range.
(9) LIMITER VOLTS control (optional with C612 and C624)	Used to control maximum voltage available to load.
(10) CAL control (screwdriver adjust)	Used, when necessary, to calibrate Range Selector switch knob settings.
(11) NULL control (screwdriver adjust)	Used, when necessary, to adjust null balance of balanced input detector.
(12) Binding posts (MOD, (+), GND, (-), REM)	Used to connect power supply to load for local or programmed operation; to make external connections for constant-voltage conversion; to make jumper connections for negative ground, positive ground, or floating output; and to apply modulation input.

Figure 2-2. Controls and Indicators

2-5. Connections to Prevent Deterioration of Regulation at the Load. When the power supply is operated at currents of 1 microampere to 10 microamperes, the shunt resistance between the two interconnecting lead wires must be greater than 100,000 megohms. These lead wires show a leakage resistance that depends on the distance between the wires and on the wire insulation. Whenever voltage is present, leakage current is present, and the leakage current becomes more significant as the load current decreases. For example: if the load current is 10 microamperes and 0.1 percent regulation is desired, the leakage current should be less than 0.01 microampere (0.1 percent of 10 microamperes). To achieve this regulation with 100 volts across the load, the leakage resistance must be greater than 10,000 megohms. Since a safety factor of at least 2 is desirable, the leakage resistance should be greater than 20,000 megohms.

2-6. Prevention of Externally Induced Ripple. Inadequate shielding of load and output lines can lead to the injection of ripple into the system. The ripple is normally greatest when the negative output is grounded. When a spurious signal is coupled into the sample resistor, the regulator amplifier maintains a constant voltage drop across the sample resistor at the expense of the load. The regulator develops a counter signal at the output, and therefore through the load,

to cancel the spurious signal. In this way, considerable ripple through the load can be caused by relatively small spurious signals injected into the sample resistor. To prevent ripple, it is of the utmost importance that the negative output lead wire and, when indicated, the load itself be adequately shielded. Shielding, must also be considered when the power is connected to an ac-line-operated device.

2-7. SELECTION OF CURRENT RANGE, PREFERRED METHOD.

When a wide current sweep or output in the 0- to 1- or 2.2-milliampere range is desired, the Range Sweep control can be set to any position. However, it is usually advisable to use the lowest Range Selector switch setting consistent with the desired output current, and to keep the Range Sweep control setting at the high end of the scale. This method is recommended because better regulation is obtained with the Range Sweep control set at the high end of the scale. For example: if the Range Selector switch is set at the low end of the scale (marked USE NEXT LOWER SWITCH SETTING) to obtain an output of 16 milliamperes. In this case, the Range Selector switch should be set at MA X10-2.2 and the Range Sweep control position should be set as required at the high end of the scale to obtain the 16-milliampere output.

NOTE

Before operating the power supply, read paragraphs 2-4 through 2-7 carefully.

2-8. LOCAL OPERATION.

Proceed as follows to operate the power supply using front panel controls:

- Be sure that **LINE** and **DC** switches are set to off position.
- Plug line-cord power connector into ac power source.
- Set **LINE** switch to on position. **LINE** indicator lamp should light.
- Connect load between (+) and (-) output binding posts.
- Set Range Selector switch for desired current output range (refer to paragraph 2-7).

CAUTION

Be sure Range Sweep control is set below desired output current value.

- With **DC** switch off, set **LIMITER VOLTS** control to desired maximum voltage as indicated by **D.C. VOLTS** meter.

NOTE

Model C612 or Model C624 may or may not be supplied with a **LIMITER VOLTS** control. The purpose of the **LIMITER VOLTS** control is to prevent an uncontrolled rise in voltage applied to the load above a specific value. However, when the **LIMITER VOLTS** control is set for a particular value, a rise in load resistance above the "knee" of the applicable **EI** curve causes a decrease in output current to below the value for which the power supply current controls are set. Effectively, the power supply becomes a constant voltage source with only moderate regulation.

- Set **DC** switch to on position. **DC** indicator lamp should light.

- Set Range Sweep control for desired current value. Panel voltmeter will indicate voltage across load plus voltage drop across internal sample resistor.

2-9. PROGRAMMED OPERATION.

The power supply output can be programmed (remotely controlled) by the use of an external resistor. A fixed resistor can be used to provide constant-current output, a series of switch-selected resistors can be used to provide discrete currents, or nonlinear potentiometers can be used to provide various waveforms.

The programming constant for a constant-current power supply is better expressed in conductance than resistance. The constant for this power supply is 200 micromhos per milliampere of output current with the Range Sweep control set at maximum. Five thousand ohms equal 200 micromhos, so a 5,000-ohm resistor allows for a 1-milliampere output. The addition of another 5,000-ohm resistor in parallel adds another milliampere to the output for a total of 2 milliamperes. The programming resistor must have an adequate power rating. Actual wattage is expressed as: power

dissipation in watts equals 5 times the load current in amperes. A safety factor of approximately 3 to 1 is recommended.

For programmed operation, set Range Selector switch to **REM**, and connect programming resistor between **REM** and (-) binding posts. (See figure 2-3.) Because load current flows through programming resistor, it is not necessary to run two lead wires to (-) binding post if programming resistor is physically located near load. A common negative line to load and programming resistor can be used. However, because (-) binding post is also sensing point, negative line must be well shielded and one end of shield must be connected to **REM** binding post.

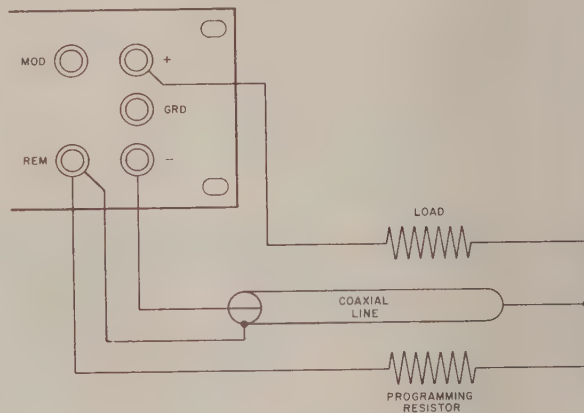


Figure 2-3. Programmed Operation

2-10. OPERATION FOR CONSTANT-VOLTAGE OUTPUT.

This constant-current power supply can be converted for constant-voltage output by the external connections shown in figure 2-4. The constant-voltage configuration provides an output as low as 5 volts with regulation of 0.05 percent. Proceed as follows:

- Set Range Selector switch to **MA X1-1**.
- Turn Range Sweep control to maximum clockwise setting.
- Select control resistor of appropriate value for desired output voltage. Value of resistor is determined by approximately 1,000-ohms-per-volt constant when Range Selector switch is set to **MA X1-1** (see schematic diagram). If exactly 1000 ohms per volt is required, recalibrate (refer to paragraph 5-4). Output voltage is equal to resistance value divided by 1,000 and added to Range Sweep control setting, or 5 volts.
- Connect resistor between (+) and (-) binding posts.
- For C612 or C624 only, connect one end of appropriate fuse (see figure 2-4) to (+) binding post. Then (for all models) connect load between free end of fuse and **REM** binding post.
- Vary output voltage, as required, by adjusting Range Sweep control or by changing value of control resistor (refer to c above).

ADDENDUM
TO
CONSTANT CURRENT INSTRUCTION
MANUAL

REVISION 1 - CORRECTIONS TO ERRATA AS INDICATED.

REVISION 2 - THE SQUARE-ROOT SCALE CORRECTION (PAGE 1).

When the switch is set to the lead open, set LIMITER
VOLT to desired maximum voltage as
indicated by the VOLTmeter.

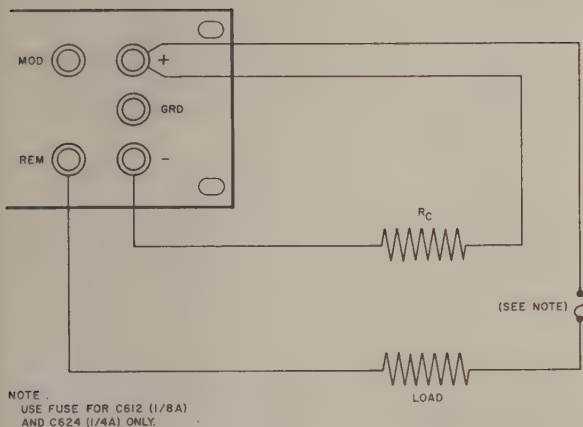


Figure 2-4. Constant-Voltage Conversion, External Connections

2-11. OPERATION WITH MODULATION.

To keep the current constant, the voltage drop across a sample resistor is kept constant. The load current goes from the plus terminal, through the load, to the negative terminal and through the sample resistor to the internal common of the power supply. This internal common is brought out of the unit through the REM terminal.

The voltage drop across the sample resistor is compared to a fixed reference voltage by the balanced input detector. The error voltage, which is amplified and applied to the series regulator tubes, is phased to develop a counter error large enough to offset the original error. Thus, constant voltage across the fixed sample resistor means constant current through the sample resistor. Because the load current flows through the load resistor and the sample resistor, and there are no current sinks or sources in the circuit, the load current is also constant.

If the reference voltage is varied, as when the Range Sweep control is rotated, the voltage drop varies across the sample resistor, and the current in the sample resistor varies correspondingly. There are two ways to vary the current. One is to vary the reference voltage, as indicated above; the other is to vary the sample resistance. Either or both methods may be used.

Modulation is varying of the reference voltage. A resistor is placed in series between the reference grid of the difference amplifier and the arm of the Range Sweep control potentiometer. If a signal is placed across this series resistor, the voltage developed adds or subtracts, as the case may be, from the reference voltage. The current increases or decreases, as indicated. For low frequencies, the amplifier is capable of following the reference changes with the output current. Thus if a 1-volt peak-to-peak signal is placed on the reference voltage, with the Range Sweep control potentiometer set to maximum setting (nominal 5 volts), the output current will vary from 95% of nominal to 105% of nominal.

As the modulating frequency increases, the amplifier is less capable of keeping the output current in phase with the modulating signal, and a phase shift develops. Also, the transconductance of the unit falls off. Eventually, at higher frequencies, there is a large phase shift, and the variation in current is only a small percentage of what it would be if the amplifier could handle the higher frequencies.

Certain precautions must be observed. One is the above-indicated frequency dependency. A second is the method by which the modulating signal is applied. One side is connected to the MOD terminal, and there is no dc isolation (capacitor) between the MOD terminal and the reference grid. Thus, the MOD terminal is always at the same potential as the reference. The other side of the signal is applied to the REM terminal, which is the internal common of the power supply. The arm of the Range Sweep control is tied to the internal common through a 25-uf, 25-volt capacitor. Thus, the load for the modulating signal is a 4.7K-ohm resistor in series with a 25-uf capacitor and at a different dc potential from either the plus output or the negative output. The modulating signal generator must be sufficiently isolated from the output terminal potential to prevent any kind of dc loop that may cause improper operation of the unit.

The balanced input detector is designed to operate with a voltage of 0 to 5 volts on both control grids. If the grid voltages are excessive, nonlinearities may result. It is recommended that the modulating signal plus the setting of the Range Sweep control never go beyond the 0- to 8-volt band.

As an alternate, an audio transformer can be wired directly across the 4.7K-ohm resistor and the modulating signal put on the transformer.

This power supply has been tested for a maximum modulation frequency of 10 kc. The modulation source should have dc isolation if its output impedance is more than 1,000 ohms. The maximum permissible amplitude of modulation is limited by the voltage on the reference grid of the power-supply balanced input detector; this voltage is determined by the Range Sweep control setting. Exceeding the limit thus established will cause progressive loss of control by the current regulation system.

Connect modulation source between the REM and MOD binding posts. At maximum Range Sweep control setting, do not exceed 6 volts peak-to-peak signal input. Maximum modulation is permissible at a Range Sweep control setting of 80 percent of maximum; at this point, 8 volts peak-to-peak is permissible. The permissible peak-to-peak signal input decreases proportionately to zero at low end of the Range Sweep control scale. Non-linear modulation signals should conform to peak-to-peak values specified above.

CAUTION

Ratings of the power supply should not be exceeded during any portion of the modulating signal.

SECTION 3 APPLICATIONS

3-1. MAGNETIC FIELD APPLICATIONS.

A constant-current power supply can be used to set and maintain a magnetic field. Magnetic flux density is a function of the number of turns of wire and the current in each turn. When a constant-voltage supply is used, the magnetic field becomes a function of the temperature of the magnet wire and, as the wire changes temperature, the resistance varies and the current and the magnetic field vary. If a constant-current power supply is used, the voltage changes as the resistance changes, and the current remains constant. The magnetic field, therefore, is unaffected by variations in magnet wire temperature.

The modulation capability of the constant-current power supply offers an additional degree of sophistication. By sensing the magnetic field, supplying the sensed information to a comparator, and using the comparator to modulate the constant-current power supply, a closed-loop control system can be devised. Figure 3-1, for example, shows a device that maintains a constant over-all magnetic field when several magnetic fields are involved (some of which may vary). Lever arm A, which is magnetic, is pivoted at one end and held by a spring at the other end. The spring tension determines the position of the arm and thereby the strength of the magnetic field. A linear potentiometer, also attached to the arm, is connected to a comparator, which measures the resistance of the potentiometer and therefore the position of the lever arm. Any change in location of the arm is transmitted to the comparator through the potentiometer, and the resultant corrective voltage is fed to the modulation input of the power supply. Thus, as individual magnetic fields vary, the system keeps the over-all magnetic field constant.

A constant-current power supply may also be used to control the precessing of a gyro. Gyros can be precessed by a magnetic field, and a constant-current

power supply, with modulation, can control a magnetic field. By using a circuit similar to that shown in figure 3-1, the rate of precessing can be adjusted and controlled.

3-2. CHECKING OPERATING VOLTAGE OF GAS TUBES AND REFERENCE DIODES.

Most gaseous devices, such as VR tubes, require a firing potential higher than the operating potential. Constant-voltage power supplies can be used, but they are frequently cumbersome and require more accessory equipment than constant-current power supplies.

To operate a gaseous device at fixed current using a constant-current power supply, simply set the power supply to the desired current. Output voltage will rise to the value required to fire the tube and then drop back to the operating voltage. Figure 3-2 shows a simple method of sorting reference tubes according to operating voltage at a given current. The constant-current power supply is set for the required current and a tube is inserted in test position. The power supply LINE switch is set to the on position and the tube is fired. Operating voltage is read from the voltmeter, and the tube is classified according to its voltage. This procedure can be adapted for more complicated tests. For example, if a life run is required to determine tube voltage changes with time, the power supply can be left on and tube voltage readings taken periodically. If the temperature is cycled, the temperature coefficient can be calculated from voltage readings.

Another test adaptation can be used to determine ac impedance. The modulation feature of the constant-current power supply makes this a simple test. Using a set-up identical to that shown in figure 3-2, except for the use of an ac voltmeter, the current supply is modulated by a known signal so that the output current has a known degree of modulation about its dc base. The ac impedance is the ac voltage across the reference tube divided by the modulation current.

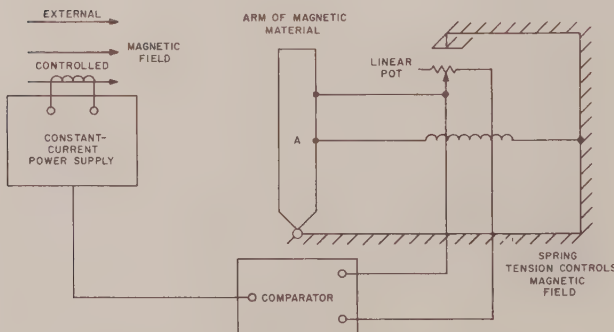


Figure 3-1. Set-up for Maintenance of Constant Over-all Magnetic Field When Several Fields are Involved

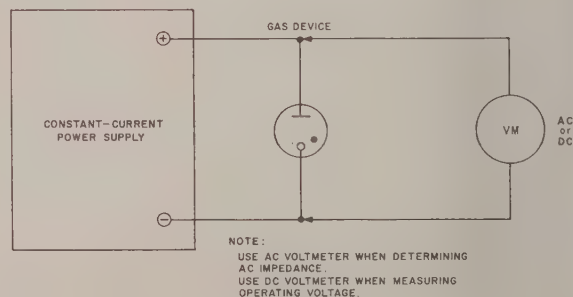


Figure 3-2. Method of Sorting Reference Tubes

The operating voltage of a reference diode is checked in the same way as the operating potential of a VR tube. Similar information is required in both cases. The only difference is in the size and range of values; reference diodes are available in many more voltage and current ranges than VR tubes. The procedure for determining ac impedance of reference diodes is similar to the procedure used for VR tubes.

3-3. MEASUREMENT OF PEAK INVERSE VOLTAGE OF SOLID-STATE JUNCTIONS.

Constant-current power supplies are of great value in testing semiconductor devices. The determination of PIV (peak inverse voltage) is difficult with a constant-voltage supply. A junction is usually specified by maximum leakage current at a specific voltage, which is the PIV. If a constant-voltage supply is used, an ammeter, a voltmeter, and a resistor in series with the junction and the voltage supply are required. With a constant-current power supply, it is necessary to have only a voltmeter across the junction. The supply is set for maximum leakage current, the junction is connected across the supply, and the voltage drop is observed on the voltmeter. By recording the voltage, the junction can be classified according to PIV. For example, assume that the junctions (see figure 3-3) are to be classified at 50-volt intervals. The diode is connected in the circuit, the power supply is turned on, and the voltmeter indication rises to 75 volts. In this case, the diode is classified as having a PIV of 50 volts. This procedure can be completely automated so that the junctions are sorted automatically.

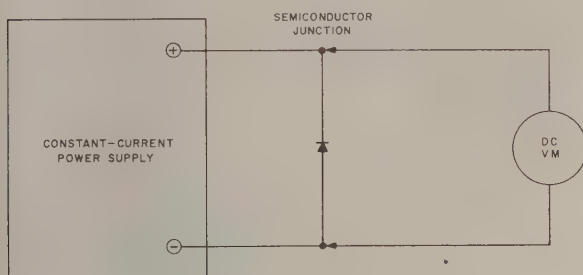


Figure 3-3. Checking PIV of Semiconductor Diodes

The forward drop test is also easily performed with a constant-current power supply, using the same circuit, but connecting the diode in the forward direction. The only difference is in the size of the values determined. Usually the PIV is a large value and the leakage current a small value, while the forward voltage drop is a small value and the forward current a large value.

3-4. TESTING RELAYS.

Many relays require little sophistication in the power supplies used to operate and test them. However, in the case of finely balanced relays where the coil current must be closely controlled, a constant-current power supply is recommended. For example, the constant-current power supply can easily be used when latch current and release current must be determined precisely. A constant-voltage supply would require an ammeter, but the calibrated constant-current supply requires no external meters.

Figure 3-4 shows a typical relay test device, where a programming potentiometer is driven by a reversible motor. Current in the relay under test is recorded. Then the motor is energized, and the current begins to increase. The relay under test closes, causing the motor to reverse, and the current begins to decrease. When the releasing current value is reached, the test relay opens, and the motor again reverses, causing the current to increase. This cycle continues and the current is continuously recorded for as long as desired.

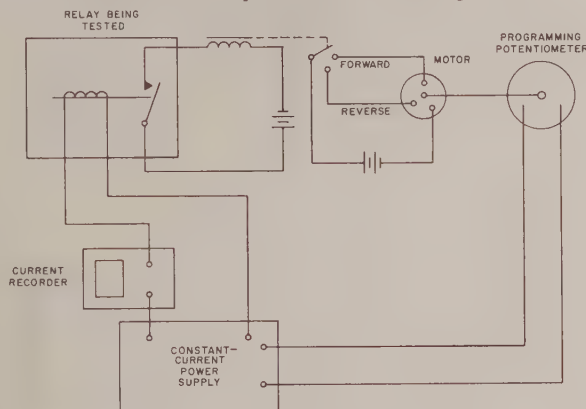


Figure 3-4. Typical Relay Test Device Using Constant Current

3-5. MISCELLANEOUS APPLICATIONS.

Constant-current power supplies can be used in generating and maintaining an accurate, stable voltage source. Most solid-state types of reference are preferably driven by a current source. If a reference diode is powered by a regulated, stabilized constant-current power supply, the voltage across the diode remains accurate and stable.

Constant-current power supplies can be used in the field of electroplating. Since plating is mechanically a process of depositing charged ions of metal on the surface of another type of metal, the number of charged ions deposited in a specific length of time must be known to control the thickness of the plating. The number of ions deposited can be determined by the length of time the associated constant-current power supply has been in operation. Especially when plating with precious metals, the amount of metal deposited is extremely important. If a constant-current power supply is used, is necessary only to use a timer during the plating process so the amount of metal deposited can be accurately computed and controlled.

In capacitor forming, a low current must be run through the capacitor. As the film is formed, the voltage increases, and it is usually desirable to keep the current constant while the voltage rises to a predetermined value. A constant-current power supply, with voltage limiter set to maximum, keeps the current constant as the voltage rises until the maximum voltage is reached. Then the voltage begins to stabilize, and the current diminishes.

The same technique is used in charging special batteries as in forming capacitors. A constant-current power supply, with voltage limiter, can be used without constant monitoring to maintain a specific current until the battery voltage is reached.

SECTION 4 CIRCUIT DESCRIPTION

NOTE

All schematics in this section have been simplified to show only essential functional circuit elements.

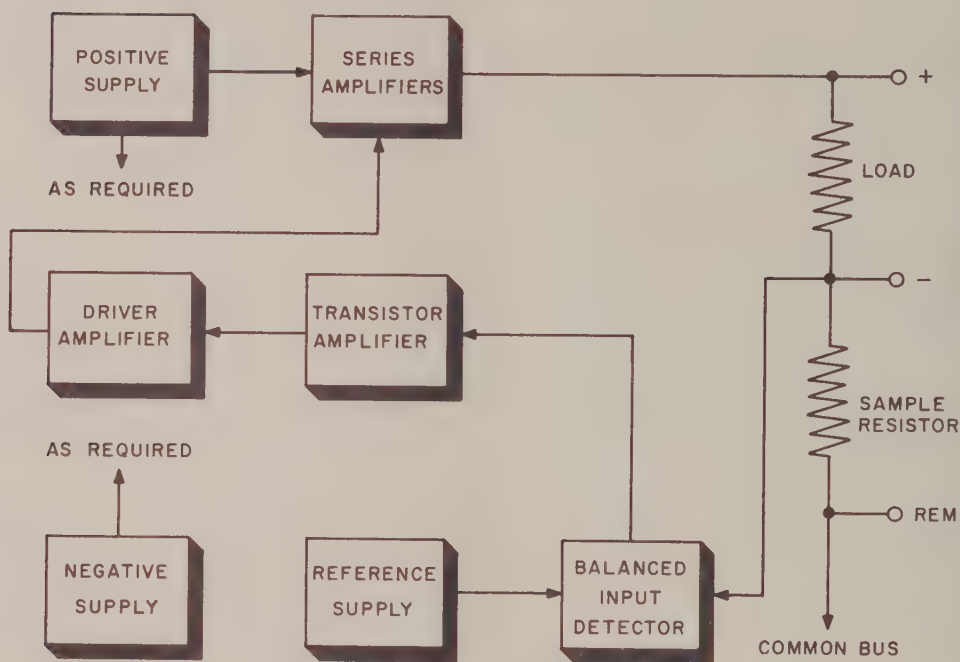


Figure 4-1. Functional Block Diagram,
Typical Regatron Constant-Current Power Supply

4-1: BLOCK DIAGRAM THEORY. (See Figure 4-1.)

Basically, the power supply consists of seven circuits, as shown in figure 4-1. These circuits function to maintain a constant voltage drop across the fixed sample resistor in series with the external load. Because the voltage across the sample resistor remains constant, the current through the resistor, and consequently through the load, also remains constant. The balanced input detector compares the voltage across the sample resistor with a stable reference voltage. Any difference between the two develops an error signal at the output of the detector. This signal is amplified and then applied, through the transistor amplifier and the driver amplifier, to the series amplifiers. The resultant change in output of the series amplifiers changes the current through the sample resistor, and therefore in the load, so that the error is reduced to zero and the rated output is maintained.

4-2. BALANCED INPUT DETECTOR CIRCUIT.

Pin 2 of balanced input detector V_A (see figure 4-2) is connected to the arm of Range Sweep control R_A , and pin 7, the sampling grid, is connected to the arm of Range Selector switch S_A . Any difference between the voltages on the two grids is amplified and appears as an

error signal at the plates. Zener diode CR_A maintains a stable 5-volt drop across the Range Sweep control. The Range Selector switch connects the selected sample resistor into the circuit. Regulated plate voltage for the balanced input detector is taken from VR tube V_B and the cathodes are returned to -150 volts regulated by VR tube V_C . NULL control R_B is used for initial null balancing of the input detector. Diode CR_B prevents triggering of the unit into a stable on condition (maximum output voltage). Capacitor C_A serves as a filter to block ac components from the reference grid.

4-3. TRANSISTOR AMPLIFIER AND DRIVER AMPLIFIER. (See figure 4-3.)

Any error signal developed and amplified by the balanced input detector is applied to transistors Q_A and Q_B . This transistorized amplifier stage is required to bias driver amplifier V_D with a negative dc voltage. Because the error signal from the balanced input detector fluctuates around a positive dc base, the base must be converted to negative dc. The conversion is accomplished by direct coupling. PNP transistors Q_A and Q_B , which use a negative collector voltage, serve as effective direct-coupling devices in this application, as well as amplifiers.

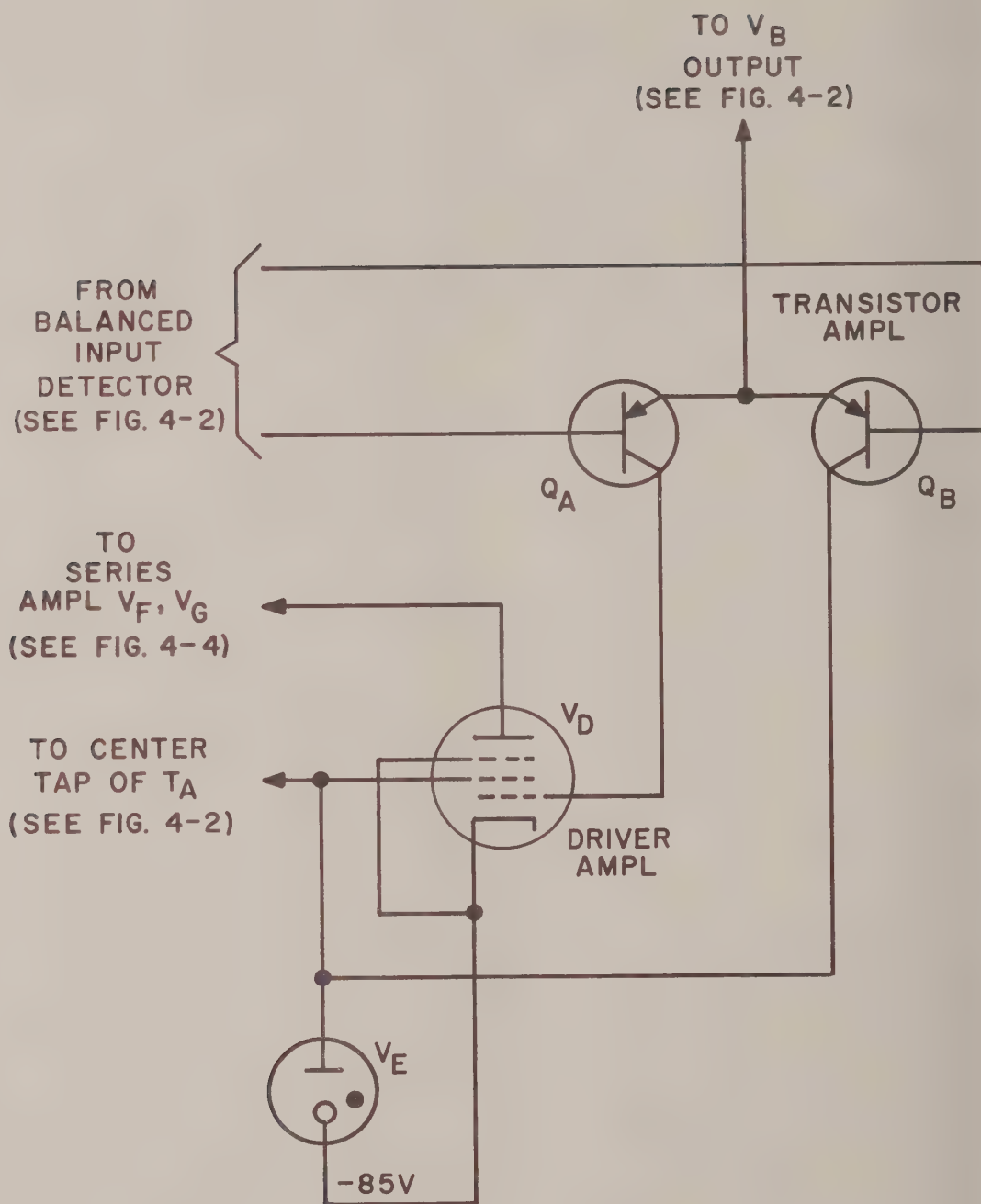


Figure 4-3. Transistor Amplifier and Driver Amplifier, Simplified Partial Schematic

Amplifier V_D provides high gain. The amplified error signal from V_D is applied to the control grids of the series amplifiers. Because the power supply is designed to start at a very low output, the output of the driver amplifier must reach approximately -45 volts to cut off the series amplifiers. The cathode of V_D is returned to -85 volts, regulated by VR tube V_E , so that there will be adequate voltage across the tube at cutoff.

4-4. SERIES AMPLIFIER. (See figure 4-4.)

Paralleled beam power tubes V_F and V_G are used as series amplifiers, or variable conductances. The control grids are direct-coupled to the output of driver amplifier V_D . (In some models, there is a cathode follower between the driver amplifier and the series amplifiers. The output of the driver amplifier is direct-coupled to the control grids of the cathode follower,

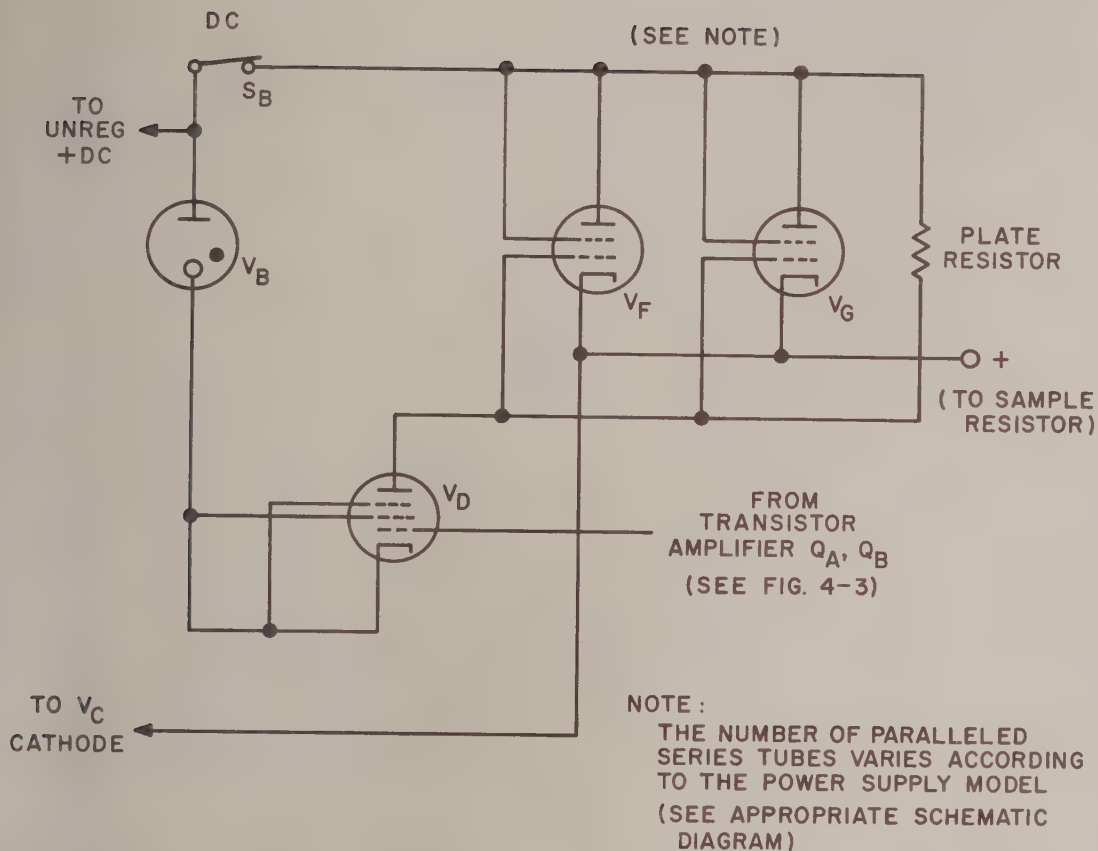


Figure 4-4. Series Amplifier Circuit, Simplified Partial Schematic

and the control grids of the series amplifiers are direct-coupled to the cathode follower.) Any error voltage at the series amplifier control grids varies the tube conductance. Thus, an increase in error voltage causes conductance of the series amplifiers to decrease. Since these amplifiers are connected in series between the unregulated positive supply and the positive output to the sample resistor, the voltage drop across the tubes increases, causing a decrease in available output voltage and a consequent decrease in current through the sample resistor. A decrease in error voltage causes a corresponding increase in conductance of the series amplifiers and a consequent increase in current through the sample resistor.

4-5. POSITIVE AND NEGATIVE SUPPLIES. (See figure 4-5.)

Transformer T_A supplies stepped-up voltages for all the rectifiers and plate and filament voltages for all electron tubes in the power supply.

The positive supply uses silicon diodes CR_C through CR_F for full-wave rectification, with filtering by resistor R_D and capacitor C_C . This supply delivers unregulated positive plate voltage for the series amplifiers and a positive service potential for the plate of amplifier V_D and the control grids of the series amplifiers. The rectified, filtered voltage is also supplied through resistor R_E to VR tube V_B so a preregulated

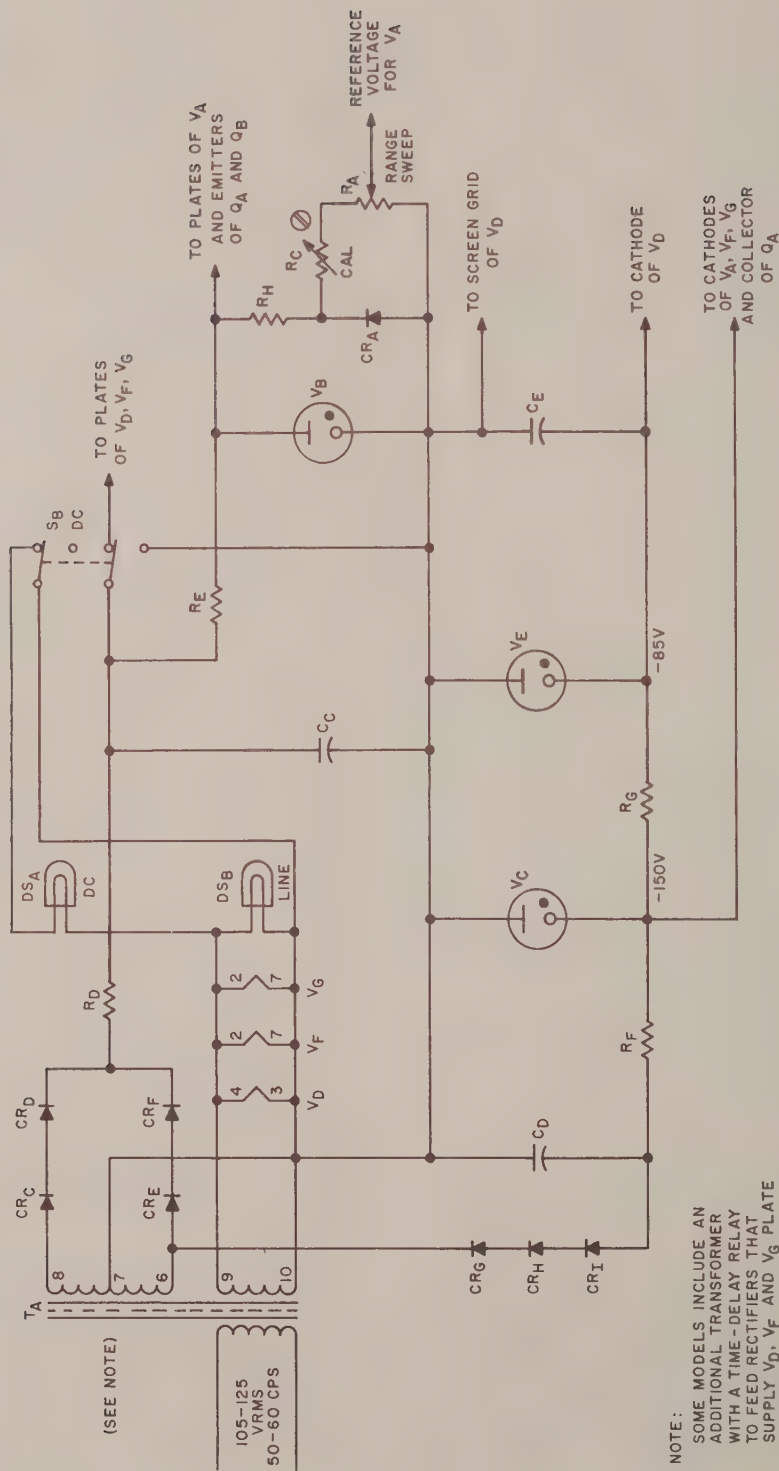
stepped-down voltage is supplied to the plates of balanced input detector V_A and the common emitters of amplifiers Q_A and Q_B . (A time-delay relay is included in the input circuit of some models in conjunction with an additional transformer that feeds special rectifiers which supply plate voltage for tubes V_D , V_F , and V_G .)

The negative supply uses a half-wave rectifier consisting of silicon diodes CR_G , CR_H , and CR_I . The rectifier output is filtered by capacitor C_D , dropped to -150 volts by resistor R_F , and preregulated by VR tube V_C . The negative potential is then dropped to -85 volts by resistor R_G and further regulated by VR tube V_E . The regulated negative voltages are used in the return circuits for balanced input detector V_A , transistor amplifier Q_A , and driver amplifier V_D to improve the over-all operating range. Capacitor C_E blocks any high-frequency ac components generated by the VR tubes from the driver amplifier screen grid.

NOTE

Models C612 and C624 have three gas regulator tubes (V_B , V_C , and V_E). All other models have five gas regulator tubes.

Ac filament voltages are supplied directly by a transformer secondary.



NOTE:
SOME MODELS INCLUDE AN
ADDITIONAL TRANSFORMER
WITH A TIME-DELAY RELAY
TO FEED RECTIFIERS THAT
SUPPLY V_D, V_F AND V_G PLATE
VOLTAGE.
(SEE APPROPRIATE SCHEMATIC
DIAGRAM)

Figure 4-5. Positive and Negative Supply Circuits, Simplified Partial Schematic

4-6. REFERENCE SUPPLY. (See figure 4-5.)

The preregulated positive voltage (refer to paragraph 4-5) is further dropped by resistor R_H and stabilized at approximately 5 volts by Zener diode CR_A to serve as the reference voltage for balanced input detector V_A . CAL control R_C permits calibration of the control system for a precise output current based on the exact potential across CR_A . The CAL control also permits periodic calibration to compensate for errors due to aging of the Zener diode and its associated components.

4-7. FILAMENT REGULATOR.

The filaments of balanced input detector V_A are regulated by a transistorized circuit that includes power transistor Q_C and signal transistors Q_D and Q_E . Regulation of the tube filament voltage is necessary because the tube characteristics vary greatly over the operating range generated by line input variations. Transistor Q_E is used as an error detector, with emitter referenced to the voltage across Zener diode CR_J . Any error signal is applied to transistor Q_D , which drives transistor Q_C to reduce the error towards zero. The regulated filament voltage can be adjusted over a small range by potentiometer R_J .

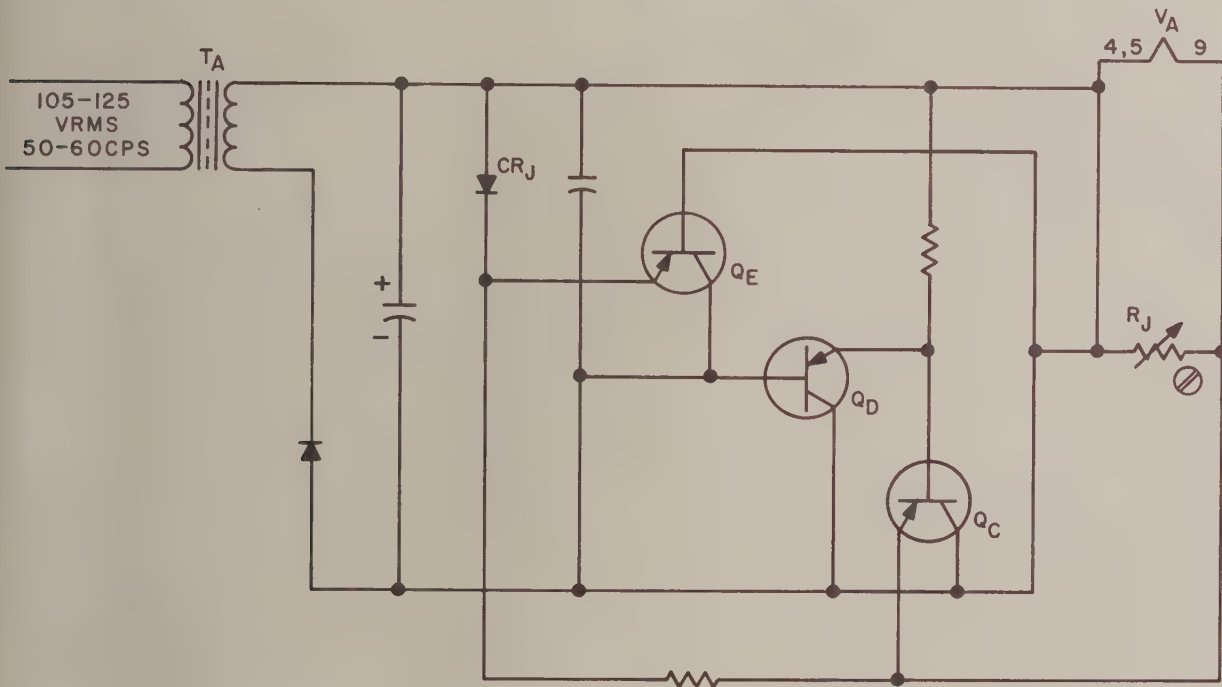


Figure 4-6. Filament Regulator Circuit, Simplified Partial Schematic

4-8. VOLTAGE LIMITER.

On models so equipped, the voltage limiter permits control of the maximum voltage available for application to the load.

The voltage limiter (see figure 4-7) incorporates a bridge-like sensing device similar to that used in EMC voltage-regulated power supplies. MAX CAL control R_L permits calibration to rated maximum voltage. Potentiometer R_K is somewhat higher than the value actually required to develop the rated maximum voltage compliance, because the potentiometer has been selected to develop the full voltage of which the power supply is capable. This voltage is higher than the rated maximum compliance.

The base of transistor Q_G senses a portion of the output voltage at the junction of the LIMITER VOLTS con-

trol and MAX CAL potentiometer. The signal at the emitter follows the voltage fluctuation sensed at the base in approximately a 1 to 1 ratio, and the signal is applied to the emitter of transistor Q_F . The base of transistor Q_F is connected to the power supply REM line through ZERO ADJ potentiometer R_M , and the transistor compares the voltage at the REM terminal with the voltage sensed at the junction of the LIMITER VOLTS control and the MAX CAL potentiometer. The resultant collector signal is applied, through diode CR_K to the control grid of high-gain amplifier V_D .

When the output voltage falls below the value set by the LIMITER VOLTS control, the sensed voltage applied to the emitter of transistor Q_F is negative with respect to the voltage at the base, which is at REM line potential; transistor Q_F therefore does not conduct; and diode CR_K is turned off and has no effect on the control grid of high-gain amplifier V_D . When the

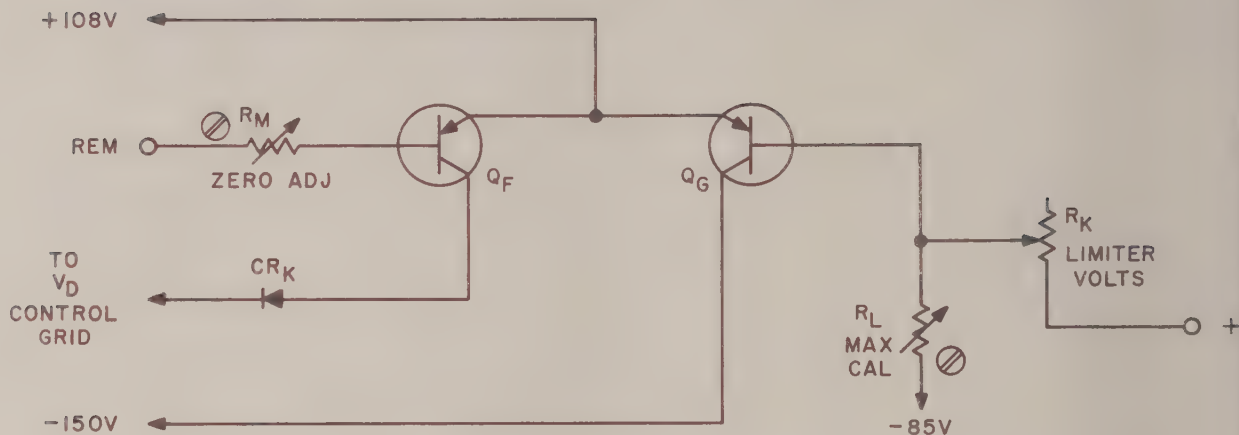


Figure 4-7. Voltage Limiter Circuit, Simplified Partial Schematic

output voltage rises to the value set by the **LIMITER VOLTS** control, the sensed voltage applied to the emitter of transistor Q_F becomes more positive than the voltage at the base. Transistor Q_F and diode CR_K conduct, and the limiter signal is applied to the control grid of V_D , thus driving the power supply regulator system to equilibrium at the voltage limiter setting. **ZERO ADJ.** potentiometer R_M permits setting the voltage limiter for zero difference between the **REM** line and the sensed voltage when the regulator system is at equilibrium.

4-9. CHOPPER STABILIZER. (See figure 4-8.)

On models so equipped, the chopper stabilizer unit continuously corrects for zero offset in balanced input detector V_A , thereby eliminating output drift. Connected across the grids of detector V_A , the chopper continuously samples the offset at pin 7 and chops it at K_A to produce a square wave, which is amplified and rectified through V_H . The output of V_H is filtered, and the resultant correction signal is applied to pin 2, thereby reducing the net offset to a negligible value.

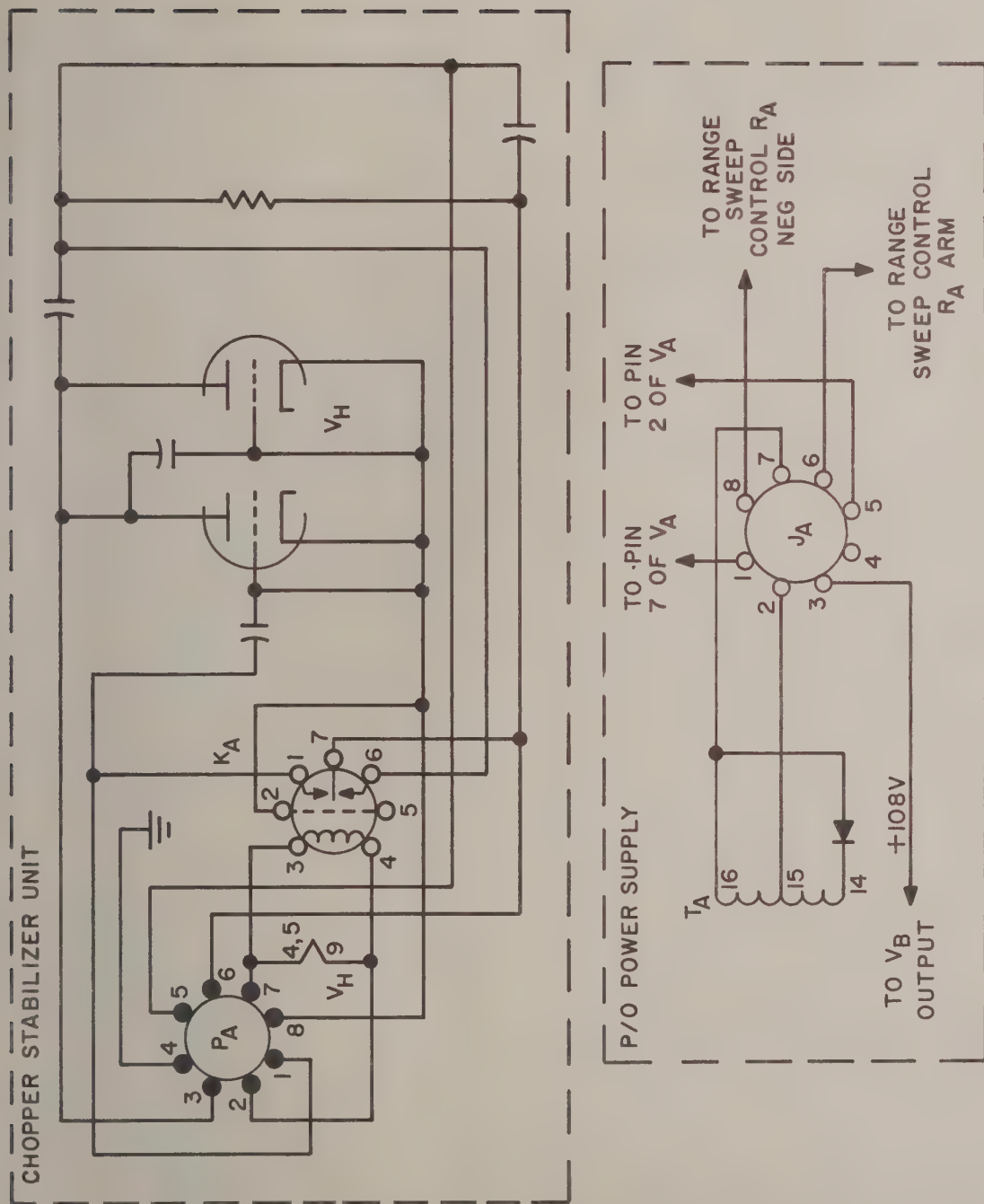


Figure 4-8. Chopper Stabilizer Circuit, Simplified Partial Schematic

SECTION 5

MAINTENANCE

5-1. GENERAL.

This section contains adjustment, calibration, and troubleshooting procedures for the power supply.

NOTE

Refer to the inside front cover of this manual for the WARRANTY under which this equipment is sold.

5-2. NULL ADJUSTMENT.

After replacement of any component in the power-supply control circuitry, check null balance of the balanced input detector as follows:

- a. Connect a jumper between (+) and (-) output binding posts.
- b. Set Range Selector switch to uA X1-1 setting, (lowest range position) and rotate Range Sweep control clockwise to maximum setting.
- c. Connect a voltmeter set for 0- to 1-vdc range between (-) and MOD binding posts.
- d. Set DC switch to on position.
- e. Adjust NULL control (screwdriver adjust) until voltmeter indicates zero.

5-3. FILAMENT REGULATOR ADJUSTMENT.

Adjust filament regulator as follows:

- a. Connect voltmeter between pin 4 or 5 and pin 9 of balanced input detector.
- b. Adjust FIL ADJ potentiometer until voltmeter indicates between 5.8 and 6.0 volts.

5-4. CALIBRATION OF OUTPUT CURRENT RANGE SETTINGS.

Calibration of the output current range settings is necessary when -85-volt VR tube, Zener diode between CAL control and Range Sweep control, or any associated voltage divider resistor is replaced. Proceed as follows:

- a. Rotate Range Sweep control clockwise to maximum setting.
- b. Connect an accurate, high-input-impedance voltmeter between REM and MOD binding posts.
- c. Adjust CAL control (screwdriver adjust) for a 5-volt indication on the voltmeter.

NOTE

Accuracy of calibration depends on accuracy of voltmeter used. Tolerance of range selector sample resistors is $\pm 1\%$; therefore, a $\pm 2\%$ meter will insure a maximum tolerance of $\pm 3\%$ of output current range settings (at maximum Range Sweep control setting).

5-5. RIPPLE MEASUREMENT.

Figure 5-1 shows the connections and procedure used for measurement of ripple in the power supply output. Lead wires should be as short as possible. The voltmeter should be completely shielded and battery operated to avoid the injection of extraneous ripple. Load and sample resistor values are selected to produce the minimum compliance voltage in accordance with the voltage compliance graph (see figure 1-2) when the Range Selector switch is set to uA X10-2.2 and the range Sweep control is set to maximum. The resistor values should change as required to develop the specified compliance for other Range Selector switch settings. The value of the load resistor is equal to the minimum compliance voltage divided by the Range Selector switch setting. The value of the sample resistor is calculated for a 5-volt drop. For a 50-volt compliance, the load-to-sample resistor ratio will be 10 to 1; for 100 volts, it will be 20 to 1.

5-6. TROUBLESHOOTING PROCEDURES.

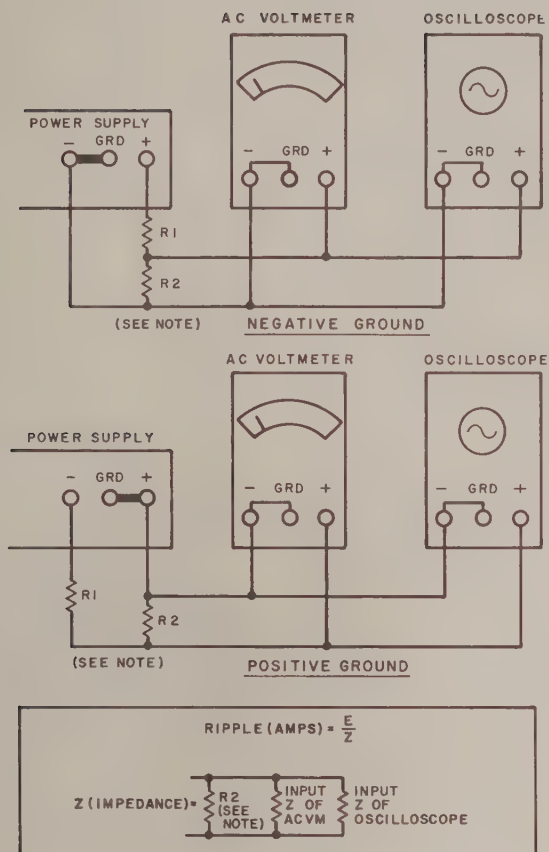
The following procedures may be used as a guide for repairing constant-current power supplies.

5-7. Preliminary Inspection. Inspect the equipment as follows:

- a. Examine unit visually for obvious troubles, such as broken wires or components.
- b. Remove all pluck-out tubes and transistors, and turn VOLTAGE LIMITER control (if supplied) to maximum setting.
- c. Connect a dc voltmeter across filament regulator (from collector of EM101 transistor to pin 9 of error detector tube).
- d. Set Variac to 5 volts ac.
- e. Set LINE switch and DC switch to on position.

CAUTION

Be extremely careful when servicing this power supply. Dangerous voltages can be developed from the low line voltage.



NOTE

RANGE	1 U A	2.2 U A	5 U A	10 U A	22 U A	50 U A	100 U A	220 U A	500 U A	1 M A	2.2 M A
R1 (OHMS)	100 M	47 M	20 M	10 M	4.7 M	2 M	1 M	470 K	200 K	100 K	47 K
R2 (OHMS)	5 M	2.27 M	1 M	500 K	227 K	100 K	50 K	22.7 K	10 K	5 K	2.27 K

RANGE	5 M A	10 M A	22 M A	50 M A	100 M A	220 M A	300 M A	500 M A	1 A	2 A	3 A
R1 (OHMS)	20 K	10 K	4.7 K	2 K	1 K	470	330	200	100	50	33
R2 (OHMS)	1 K	500	227	100	50	22.7	16.6	10	5	2.5	1.67

Figure 5-1. Set-up for Ripple Measurement

f. Use a multimeter to check voltages across all electrolytic capacitors. Make any necessary repairs or replacements.

NOTE

If unit has time-delay relay, it must be actuated manually to check voltages across screen voltage capacitor and main power capacitor.

g. Set Variac for 125 volts ac. If unit has a time-delay relay, allow time for relay to actuate.

h. Check voltage across all electrolytic capacitors for proper value and to be sure that no capacitor is operating above its rating.

5-8. Checking Filament Regulator. Check filament regulator as follows:

a. Plug in 2N1372 transistors that were removed from filament regulator section (refer to paragraph 5-7b). These must be 25-volt, PNP, medium Beta transistors, or equivalent.

b. Plug in 12AY7 error detector (input) tube.

c. Connect a dc voltmeter across filament regulator (from collector of EM101 transistor to pin 9 of error detector tube).

d. Set LINE switch to on position, and set Variac for 105 volts ac. Dc voltmeter should indicate approximately 10 ± 0.5 volts. If voltmeter indication is not as specified, disconnect voltmeter from pin 9 of error detector and connect it to pin 4 or 5.

e. Set Variac for 125 volts ac. Dc voltmeter should indicate approximately 12.5 ± 0.5 volts. If voltmeter indication is not as specified, check wiring from dc connections to filter of dc voltage filament regulator. Make any necessary repairs.

f. Connect dc voltmeter across filament of error detector (pin 9 to pin 4 or 5).

g. Adjust Variac for a dc voltmeter indication of 5.8 to 6 volts. If satisfactory adjustment cannot be made, proceed as follows:

- (1) Remove one end of 30-ohm resistor in parallel with EM101 transistor.
- (2) Remove two 2N1372 transistors. Filament voltage should fall to zero. If it does not, check filament regulator section for proper connections, and check EM101 transistor for short.
- (3) Replace first 2N1372 (driver) transistor. Filament voltage should rise to maximum input voltage. If it does not, check replaced 2N1372 transistor.
- (4) Replace second 2N1372 transistor. If regulator does not operate, check second transistor. Make any necessary repairs.

h. Vary line voltage from 105 to 125 volts ac. Filament regulator voltage should not vary more than 150 millivolts.

i. Set LINE switch to off position.

5-9. Checking Positive and Negative Supply Voltages. If power supply incorporates a chopper stabilizer, remove chopper module, and place a short between pin 5 and pin 6 of chopper stabilizer socket.

a. Plug in gas regulator tubes (two OA2's and one 85A2 for C612 and C624; for all other models two OA2's, two OB2's, and one 85A2).

b. Set LINE switch to on position.

c. Check that all three gas regulator tubes glow. Then vary line voltage from 100 to 130 volts ac. Gas regulator tubes should continue to glow.

d. If any gas regulator tubes do not glow, one of the following probably applies:

- (1) Tube has abnormally high starting voltage. Check voltage across tube. If operating voltage is higher than normal, replace tube.
- (2) Incorrect wiring has partially or completely shorted tube. In this case, voltage across tube will be abnormally low. Check wiring and make necessary repairs.

(3) Socket may be improperly soldered. Check voltage across tube from copper side of PC board, and check voltage across tube by removing tube and inserting probe in socket holes. If voltages do not match, socket is probably improperly soldered.

e. Set LINE switch to off position, and make necessary repairs.

5-10. Preliminary Balancing of Amplifier. Proceed as follows:

a. Set Range Selector switch to REM position.

b. Connect jumper between (+) and REM terminals, and connect jumper between (-) and MOD terminals.

c. Plug in 2N2191 amplifier transistors.

d. Connect dc voltmeter between pin 1 of 6AU6 tube (pin 4 of 6842 tube for models of 1000 or more volts compliance, such as C638) and REM terminal. (Use probes in tube socket and at REM terminal).

e. Set LINE switch to on position.

f. After equipment has warmed up for about 15 minutes, rotate NULL control from maximum to minimum (fully clockwise to fully counterclockwise). Dc voltmeter indication should vary from about -70 volts to about -100 volts. If voltage does not vary as specified, check the input stage and the transistor amplifier stage as follows:

- (1) Remove 12AY7 tube and 2N2191 amplifier transistors, and make a point-to-point check between sockets and PC board copper to be sure that sockets are properly soldered.
- (2) Check wiring from NULL control to PC board.
- (3) Check wiring from grids of 12AY7 tube to MOD and (-) output terminals.
- (4) Check 2N2191 amplifier transistors.
- (5) Check 830K-ohm and/or 330K-ohm collector resistors of 2N2191 amplifier for proper value.
- (6) Check 22K-ohm plate resistors of 12AY7 tube and 22K-ohm emitter resistor of 2N2191 amplifier transistors.

g. Set LINE switch to off position, and make necessary repairs.

h. Plug in 6AU6 tube (6842 for models of 1000 or more volts compliance), and connect dc voltmeter between pin 5 of 6AU6 tube (6842 for models of 1000 or more volts compliance) and REM terminal.

i. Set LINE switch to on position.

j. Vary NULL control from maximum (fully clockwise) to minimum (fully counterclockwise). Voltmeter indication should vary from about -40 volts to +150 volts over a very small range of NULL control rotation. If the voltage does not vary as specified, check 6AU6 tube (6842 for models of 1000 or more volts compliance) as follows:

- (1) Check that tube socket is properly soldered.
- (2) Check value of plate resistor and grid divider resistors.

k. For units that have a cathode follower between final amplifier and series dropping tubes, plug in 12AX7 cathode follower. Then proceed as follows:

- (1) Connect dc voltmeter between REM terminal and cathode of 12AX7 cathode follower.
- (2) Set LINE switch to on position, and wait for equipment to warm up.
- (3) Rotate NULL control from maximum to minimum. Voltage should vary from about -40 volts dc to about +150 volts dc over a very short rotation of NULL control. If voltage does not vary as specified, 12AX7 cathode follower is defective. In this case, check 12AX7 tube, and associated wiring and components.
- (4) Turn LINE switch to off position, and make any necessary repairs.

l. Set LINE switch to off position, and make necessary repairs.

m. Plug in one series tube and remove jumper from (+) and REM terminals.

n. If power supply has no meters, connect a dc voltmeter between (+) and REM terminals.

o. Set LINE switch to on position and wait about 15 minutes for equipment to warm up.

p. Rotate NULL control from maximum to minimum (fully counterclockwise). Dc voltmeter indication should vary from zero or slightly negative to maximum rating of power supply output.

q. If voltage does not vary as specified in p above, check series deck and wiring for the following:

- (1) Defective dc fuse.
- (2) Defective series tube.
- (3) Defective wiring.
- (4) Poor solder joints.
- (5) Incorrect component.

r. Set LINE switch to off position, and make any necessary repairs.

s. Replace all series tubes, and repeat steps 1 through q.

t. Set LINE switch to off position, make additional repairs, if required, and remove jumpers from output terminals.

5-11. Checking Range Selector. Proceed as follows:

a. Set power supply current controls for 10-milliampere output.

b. Connect jumper between (+) and (-) output terminals.

c. Connect bucking meter between (-) and MOD terminals.

d. Set LINE switch to on position and allow about 15 minutes for equipment to warm up.

e. Set DC switch to on position, and adjust NULL control for a bucking meter indication of zero.

f. Set DC switch to off position, and turn Range Sweep control to maximum clockwise setting.

g. Connect a high-impedance dc voltmeter (0.5% accuracy) between REM and MOD terminals.

h. Adjust CAL control for an indication of 5 volts dc on the meter.

i. Remove jumper from (+) and (-) terminals and substitute an ammeter (multimeter).

j. Set DC switch to on position, and check current at all Range Selector switch settings for correct value. This procedure will check out the value and location of all Range Selector resistors.

5-12. Checking Voltage Limiter. Proceed as follows if the power supply is supplied with a LIMITER VOLTS control:

a. Check associated wiring, particularly the limiter potentiometer and the CAL potentiometer.

b. Plug in the limiter components (two 2N398 transistors, or one 2N398 transistor and a 12AX7 tube).

c. Disconnect any loads from output terminals. Set LINE switch to on position and wait about 15 minutes for equipment to warm up.

d. Set DC switch to on position, and turn LIMITER VOLTS control to maximum clockwise setting. Voltage (as indicated by D. C. VOLTS meter) should rise to maximum.

e. Turn LIMITER VOLTS control slowly towards zero. Voltage should begin to drop when LIMITER VOLTS control reaches 90 degrees of rotation.

f. Turn LIMITER VOLTS control to the two-thirds counterclockwise position. If voltage has not dropped, the limiter is defective, and the trouble is probably one of the following:

- (1) Reference resistor not installed.
- (2) Diode switch between 6AU6 tube (6842 for models of 1000 or more volts compliance) and collector of limiter transistor not operating.
- (3) Defective limiter transistor.

g. Set LINE switch to off position, make necessary repairs, and recheck (steps c through f above).

h. With limiter operating, check for oscillation. If there is oscillation, one or more of the following may be required:

- (1) Change of capacitor across collector resistor of limiter transistor.
- (2) Insertion of capacitor between positive output and arm of control potentiometer.
- (3) Insertion of capacitor between positive output and collector of transistor that drives tube 6AU6 (6842 for models of 1000 or more volts compliance).

5-13. Checking Chopper Stabilizer. If the power supply has provision for a chopper stabilizer, proceed as follows:

- a. With power supply in operation, remove short from pins 5 and 6 of chopper socket.
- b. Check wiring to be sure that 120K-ohm resistor and two 25-uf, 25-volt capacitors are installed.
- c. Plug in chopper module, and plug 12AX7 tube and mechanical chopper into module.
- d. Set LINE switch to on position, and wait approximately 15 minutes for equipment to warm up.
- e. Connect ammeter between (+) and (-) terminals.
- f. Adjust Range Selector switch for 10-milliamper output.
- g. Connect bucking meter between (-) output terminal and arm of Range Sweep control.

h. Set DC switch to on position, and turn Range Sweep control to maximum clockwise setting.

i. Wait a few minutes until chopper has settled. Then check bucking meter. Meter indication should be close to zero.

j. Rotate NULL control back and forth. Bucking meter should indicate abrupt change, but should return to within a few millivolts of previous indication.

k. If indications are not as specified in steps i and j above, one or more of the following is probably causing the trouble:

- (1) Defective mechanical chopper.
- (2) Defective 12AX7 tube in chopper.
- (3) Defective filter capacitor in chopper.
- (4) Defective wiring.

l. After checking chopper operation, remove chopper module, replace short between pins 5 and 6 of chopper socket, and reset NULL control for zero on bucking meter. Then remove short from pins 5 and 6 of socket, and replace chopper module.

NOTE

Power supply should always operate with minimum output from chopper.

SECTION 6

PARTS LIST, DIAGRAMS, AND CHARTS

6-1. PARTS LIST.

An electrical parts list is provided in this section to facilitate replacement of defective parts. This list includes recommended spares in the quantity of one per reference symbol except for fuses, which are three per reference symbol. The recommended spares are identified on the parts list by an asterisk (*). For additional information, refer to Notes at the end of the parts list.

6-2. DIAGRAMS AND CHARTS.

The following illustrations and charts are included in this section for reference during maintenance and repair:

- a. Parts location illustrations (figures 6-1, 6-2, and 6-3).
- b. Outline drawing (figure 6-4).
- c. Voltage and resistance charts (figure 6-5).
- d. Schematic diagram (included with parts list at the end of the book).

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REGATRON MODEL C612A
DATE 9/62

VOLTAGES

CONDITIONS FOR VOLTAGE MEASUREMENT:

1. LINE and DC switches on.
2. Range selector at MA X1-1
3. Current control at maximum.
4. Limiter control at maximum.
5. Output floating.
6. Line voltage at 115 volts.
7. Use VTVM or TVM.
8. Measurements from REM terminal to points indicated.

TRANSFORMER	BETWEEN TERMINALS (AC VOLTS)							
T								
T								
T								

TUBE	TUBE PIN (DC VOLTS)								
	1	2	3	4	5	6	7	8	9
V104	+108	0	0	0	+108	0	0		
V105		-150	0	-150	0	0	-150		
V106	0	-85	0	-85	0	0	-85		
V107	-86	-85	0	6.3ac	+80	-50	-85		
V108	+90	+5	+6	+5.8	+5.8	+90	+5	+6	0
V101		6.3ac	+300	+300	+70	0	0	+100	
V102		6.3ac	+300	+300	+70	0	0	+100	
V									
V									
V									
V									
V									
V									
V									
V									

TRANSISTOR	TRANSISTOR LEAD (DC VOLTS)		
	E	B	C
Q104	+90	+90	+65
Q105	+90	+90	+60
Q101*	+5.8	+5.9	+11
Q102*	+5.9	+5.8	+11
Q103*	+5.8**	+5.8	+5.9
Q			

DIODE	ACROSS	DC VOLTS	DIODE	ACROSS	DC VOLTS
CR			CR		
CR			CR		
CR			CR		
CR			CR		
CR			CR		
CR			CR		

*Measure from positive lug of C7 to point indicated.
**Voltage of Zener diode.

Figure 6-5. Chart of Voltages and Resistances C612, C624 (Sheet 1 of 2)

PARTS LIST

MODELS C612A, C612AK, C612AL, C612AKL

Programming Constant:
200 umhos per ma; Input: 115 volts, 50-60 cps

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
C1, C2	Capacitor, fixed, electrolytic, 120 uf, 450 VDC.	D32346	Sprague
C3	Capacitor, fixed, electrolytic, 25 uf, 25 VDC (used on chopper units only).	ENW530	Shelmar
CR1, CR2, CR3, CR4	Rectifier, silicon	EM803	Rowan Cont. Co.
DS1, DS2	Lamp, incandescent	44	G. E.
E1, E2, E3, E4, E5	Binding post, low loss mica.	9738-19.	Eby
E6	Link, shorting	938-L	General Radio
F1	Fuse, cartridge, 2A.	3AG	Sightmaster
J1	Socket, octal, low loss (used on chopper units only).	9751-9	Eby
M1	Voltmeter, 0-300 VDC (not used on units with limiter)	346C60-10.	Rowan Cont. Co.
P1	Cable assy. 7 ft. long, No. 18GA, 3 Cond., 3 prong plug.	346B193-1.	Rowan Cont. Co.
R1	Resistor, fixed, WW, 5 ohms $\pm$ 5%, 3 W.	3X5	Ward Leonard
R2	Resistor, fixed, comp., 120K ohms $\pm$ 10%, 1/2 W (used on chopper units only)	EB1241	Allen-Bradley
R3	Resistor, fixed, WW, 11K ohms $\pm$ 5%, 10 W	10KT	Sprague
R6	Resistor, fixed, WW, 7K ohms $\pm$ 5%, 20 W	1838	Ohmite
R7	Resistor, variable, WW, 10K ohms, 3/8 shaft, series 43	CM26801.	Clarostat
R8	Resistor, variable, WW, 10K ohms, 1/8 shaft, series 43	CM18924.	Clarostat
R9	Resistor, variable, WW, 1.5 K ohms, 1/8 shaft, series 43	CM25102.	Clarostat
R10	Resistor, variable, WW, 150K ohms, 1/2 shaft, series 53, (used on units with limiter only)	CM29578.	Clarostat
S1	Switch, toggle, SPST	160-73	Carling Elect.
S2	Switch, toggle, DPDT	2GL53-73	Carling Elect.
T1	Transformer, power	5081	Rowan Cont. Co.
TB1	Terminal board, 5 lug, low loss	601Y5-HL	Kulka
XDS1	Light, indicator, holder, green faceted lens	100G	DMC
XDS2	Light, indicator, holder, red faceted lens	100R	DMC
XF1	Fuse holder	342004	Littlefuse
C101, C106	Capacitor, fixed, film, .001 uf, 200 VDC	107C102K	Gen. Instru.
C102	Capacitor, fixed ceramic, .001 uf, 50 VDC	40C214	Sprague
C103	Capacitor, fixed, mica, .001 uf, 500 VDC	CM30C102J.	Gen. Instru.
C104	Capacitor, fixed, elect. 1000 uf, 5 VDC.	625BP1000-15	NE
C105	Capacitor, fixed, ceramic, 0.1 uf, 50 VDC	33C41	Sprague
C107	Capacitor, fixed, paper, .05 uf, 600 VDC	PI61N157	Aerovox
C108	Capacitor, fixed, film, .01 uf, 200 VDC	107C103K	Gen. Instru.
C109	Capacitor, fixed, electrolytic, 25 uf, 25 VDC	ENW530	Shelmar
CR101, CR104, CR105	Rectifier, silicon	EM801.	Rowan Cont. Co.
CR102	Diode, silicon, stabistor.	EM605.	Rowan Cont. Co.
CR103	Diode, silicon, zener	EM601.	Rowan Cont. Co.
CR106	Diode, silicon, zener	EM604.	Rowan Cont. Co.
Q101	Transistor, silicon, NPN	EM302.	Rowan Cont. Co.
Q102, Q103	Transistor, silicon NPN	EM306.	Rowan Cont. Co.
Q104, Q105	Transistor, germanium, PNP	EM502.	Rowan Cont. Co.
R107, R108	Resistor, fixed, comp., 470 ohms $\pm$ 10%, 1/2 W	EB4711	Allen-Bradley
R110	Resistor, fixed, comp., 4.7 M ohms $\pm$ 10%, 1/2 W	EB4751	Allen-Bradley
R111	Resistor, fixed, comp., 12 K ohms $\pm$ 10%, 1 W	GB1231	Allen-Bradley
R112	Resistor, fixed, comp., 330 K ohms $\pm$ 10%, 1/2 W	EB3341	Allen-Bradley
R113	Resistor, fixed, comp., 390 K ohms $\pm$ 10%, 1/2 W	EB3941	Allen-Bradley
R114	Resistor, fixed, comp., 82 K ohms $\pm$ 10%, 2 W	HB8231	Allen-Bradley
R115	Resistor, fixed, comp., 15 K ohms $\pm$ 10%, 1/2 W	EB1531	Allen-Bradley
R116	Resistor, fixed, D.F., 830 K ohms $\pm$ 1%, 1/2 W	MEB.	IRC
R117	Resistor, fixed, D. F., 330 K ohms $\pm$ 1%, 1/2 W	MF-1/4	Dale
R118, R121, R122	Resistor, fixed, D. F., 22 K ohms $\pm$ 1%, 1/2 W	MF-1/4	Dale
R119	Resistor, fixed, D. F., 100 K ohms $\pm$ 1%, 1/2 W	MF-1/4	Dale
R120	Resistor, fixed, comp., 51 K ohms $\pm$ 10%, 1/2 W	EB5131	Allen-Bradley
R123	Resistor, fixed, WW, 2.5 ohms $\pm$ 5%, 3 W.	3X2.5	WL
R124	Resistor, fixed, comp., 18 K ohms $\pm$ 10%, 1/2 W	EB1831	Allen-Bradley

REFERENCE SYMBOL	DESCRIPTION		TYPE OR PART NO.	MANUFACTURER
R125.	Resistor, fixed, WW, 30 ohms, $\pm 5\%$, 5W	5X30	WL	
R126.	Resistor, fixed, comp., 560 ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB5611	Allen-Bradley	
R127.	Resistor, fixed, comp., 2.2K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB2221	Allen-Bradley	
R128.	Resistor, variable, WW, 1K ohms, P.C. type	39-010	Ciarostat	
R129.	Resistor, fixed, comp., 220 ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB2211	Allen-Bradley	
R130.	Resistor, fixed, comp., 5.1K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB5121	Allen-Bradley	
R131.	Resistor, fixed, comp., 330 ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB3311	Allen-Bradley	
R132.	Resistor, fixed, DF, 100K ohms $\pm 1\%$, $\frac{1}{2}$ W.	MF- $\frac{1}{4}$	Dale	
R133.	Resistor, fixed, comp., 4.7K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB4721	Allen-Bradley	
R134.	Resistor, fixed, comp., 10K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB1031	Allen-Bradley	
V101				
V102	Electron Tube	6L6GB.	Sylvania	
V104.	Electron tube	OB2.	RCA	
V105.	Electron tube	0A2.	RCA	
V106.	Electron tube	85A2/0G3	Ampx.	
V107.	Electron tube	6AU6	RCA	
V108.	Electron tube	12AY7.	G. E.	
XQ101, XQ102, XQ103, XQ104, XQ105.	Socket, transistor	3303	Elco.	
XV101, XV102.	Socket, novar	497B29	Connector Corp.	
XV104, XV105, XV106, XV107				
XV108.	Socket, 7 pin miniature.	111-51-11-065.	Cinch-Jones	
R301.	Resistor, fixed, DF, 5 M ohms $\pm 1\%$, 2W.	121-51-11-055.	Cinch-Jones	
R302.	Resistor, fixed, D.F., 2.27M ohms $\pm 1\%$ 1 W.	9849-2	Weston	
R303.	Resistor, fixed, D.F., 1M ohms $\pm 1\%$, $\frac{1}{2}$ W.	MF-1	Dale	
R304.	Resistor, fixed, D.F., .5 M ohms $\pm 1\%$, $\frac{1}{2}$ W.	RN70C.	WL	
R305.	Resistor, fixed, D.F., .227M ohms $\pm 1\%$, $\frac{1}{2}$ W.	9852	Weston	
R306.	Resistor, fixed, D.F., 100K ohms $\pm 1\%$, $\frac{1}{2}$ W.	MF- $\frac{1}{4}$	Dale	
R307.	Resistor, fixed, WW, 50 K ohms $\pm 1\%$, 5 W.	RS-5	Dale	
R308.	Resistor, fixed, WW, 22.7 K ohms $\pm 1\%$, 3 W.	RS-2	Dale	
R309.	Resistor, fixed, WW, 10K ohms $\pm 1\%$, 3 W.	RS-2B.	Dale	
R310.	Resistor, fixed, WW, 5 K ohms $\pm 1\%$, 3 W.	RS-2B.	Dale	
R311.	Resistor, fixed, WW, 2.27 K ohms $\pm 1\%$, 3 W.	RS-2B.	Dale	
R312.	Resistor, fixed, WW, 1 K ohms $\pm 1\%$, 3 W.	RS-2B.	Dale	
R313.	Resistor, fixed, WW, 500 ohms $\pm 1\%$, 3 W.	RS-2B.	Dale	
R314.	Resistor, fixed, WW, 227 ohms $\pm 1\%$, 3 W.	RS-2	Dale	
R315.	Resistor, fixed, WW, 100 ohms $\pm 1\%$, 3 W.	RS-2	Dale	
R316.	Resistor, fixed, WW, 50 ohm $\pm 1\%$, 3 W.	RS-2	Dale	
S301.	Switch, rotary, 20 $^{\circ}$, index, 18 position.	349A8	Rowan Cont. Co.	

ADDENDUM FOR
198-242 VRMS 50-60 CPS INPUT

F1.	Fuse, cartridge, 1A	3AG.	Sightmaster
T1.	Transformer, power	5183	Rowan Cont. Co.

CHOPPER STABILIZER FOR CONSTANT CURRENT MODELS
("K" DESIGNATION)

C401.	Capacitor, fixed, mica, 27 uuf, 500 VDC	CM20C270J.	Gen. Instru.
C402, C403, C404	Capacitor, fixed, paper, .022uf, 200 VDC	118C223K	Gen. Instru.
C405.	Capacitor, fixed, non-polar., 20uf, 25 VDC	CL27BG200UN3	IEI
CR401, CR402.	Rectifier, silicon	EM802	Rowan Cont. Co.
R401.	Resistor, fixed, comp., 120K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB1241.	Allen-Bradley
R402.	Resistor, fixed, comp., 33K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB3331	Allen-Bradley
R403, R406.	Resistor, fixed, comp., 4.7 M ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB4751	Allen-Bradley
R404.	Resistor, fixed, comp., 100 K ohms $\pm 10\%$, 1/2 W.	EB1041	Allen-Bradley
R405, R407.	Resistor, fixed, comp., 680K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB6841	Allen-Bradley
R408.	Resistor, fixed, comp., 56K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB5631	Allen-Bradley
R409.	Resistor, fixed, comp., 270K ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB2741	Allen-Bradley
R410.	Resistor, fixed, comp., 1 M ohms $\pm 10\%$, $\frac{1}{2}$ W.	EB1051	Allen-Bradley
K401.	Chopper, SPDT.	175.	Airpax
P402.	Plug, Octal	204-52-08-005.	Cinch-Jones
V401.	Electron tube.	12AY7.	G. E.
XV401	Socket, noval.	121-11-12-035.	Cinch-Jones
XK401	Socket, 7 pin min.	111-11-10-023.	Cinch-Jones

LIMITER FOR CONSTANT CURRENT MODELS
("L" DESIGNATION)

C601.	Capacitor, fixed, paper, .022uf, 200 VDC	118C223K	Gen. Instru.
CR601	Rectifier, silicon	EM801	Rowan Cont. Co.

REFERENCE SYMBOL	DESCRIPTION	TYPE OR PART NO.	MANUFACTURER
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LIMITER FOR CONSTANT CURRENT MODELS
("L" DESIGNATION)

Continued

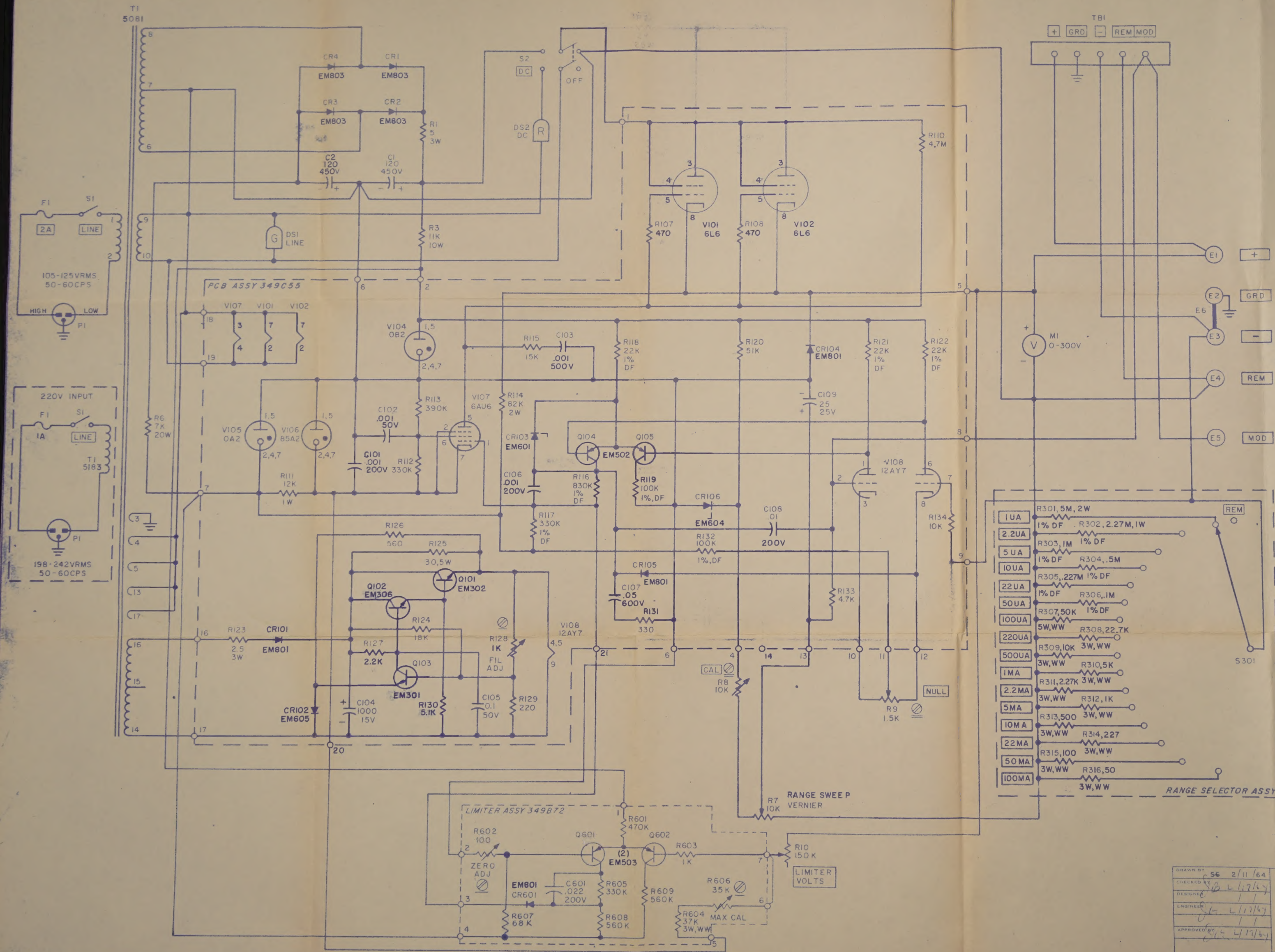
Q601, Q602.	Transistor, germanium, PNP					2N398A		MOT
R601.	Resistor, fixed, comp.,	470K ohms $\pm$ 10%, $\frac{1}{2}$ W.				EB4741		Allen-Bradley
R602.	Resistor, variable, WW,	100 ohms, P.C. type				39-010		ClaroSTAT
R603.	Resistor, fixed, comp.,	1 K ohms $\pm$ 10%, $\frac{1}{2}$ W.				EB1021		Allen-Bradley
*R604.	Resistor, fixed, WW, 37	K ohms $\pm$ 1%, 3 W.				TX3724		PRC
R605.	Resistor, fixed, comp.,	330 K ohms $\pm$ 10%, $\frac{1}{2}$ W.				EB3341		Allen-Bradley
*R606.	Resistor, variable, WW,	35 K ohms, 3/8 shaft, series				43.CM 27128		ClaroSTAT
R607.	Resistor, fixed, comp.,	68 K ohms $\pm$ 10%, $\frac{1}{2}$ W.				EB6831		Allen-Bradley
*R608, *R609.	Resistor, fixed, comp.,	560 K ohms $\pm$ 10%, $\frac{1}{2}$ W.				EB5641		Allen-Bradley
XQ601, XQ602.	Socket, transistor					3303		Elco

*Nominal value shown, actual value determined at test.

NOTES:

1. REPLACEMENTS: Part numbers indicate stock employed at time this parts list was compiled. Unless otherwise noted, and except for Electronic Measurements (EM) numbers, "or equal" parts may be used for replacement. Electronic Measurements, A Division of Rowan Controller reserves the right to replace a part with an "or equal" part number.
2. ORDERING PARTS FROM ELECTRONIC MEASUREMENTS: Include model and serial numbers of the power supply. If there is a discrepancy between parts list number and number actually printed on the part, use the latter.
3. STORAGE OF ELECTROLYTIC CAPACITORS: When electrolytic capacitors are to be stored as spares for a year or more, request Technical Note 32.
4. SELECTED PARTS: The value of certain components, specified by a note on the schematic diagram, are selected at final test.

REVISIONS				
REV	DESCRIPTION	DATE	BY	CHK
A	REDRAWN REPLACES REVISION NO 1305 (0605) WITH CHANGE EFFECTIVE SER NO 1305 (0605)	2-1-64	SG	
B	REV PER ECO-0612	3-3-64	SG	
C	REV PER ECO-0655 (EFF SER No. 1696)	6-5-64	DA	
D	REV PER ECO NO. 0794	3-30-65	AP	
E	REV PER ECO-0902	9-21-65	SB	



- NOTES: (*)
1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCE VALUES IN OHMS ALL CAPACITANCE VALUES IN MICROFARADS. ALL RESISTORS ARE 1/2 WATT. K=1,000 M=1,000,000
 2. DENOTES SCREWDRIVER ADJ ON FRONT PANEL
 3. DENOTES EQUIPMENT MARKING.
 4. DENOTES SCREWDRIVER ADJ ON CHASSIS
 5. NOMINAL VALUE SHOWN, ACTUAL VALUE DETERMINED AT TEST.

NOV 10 1965

DRAWN BY	SG 2/11/64
CHECKED BY	SG 2/17/64
DESIGNED BY	SG 2/17/64
ENGINEER	SG 2/17/64
APPROVED BY	SG 2/17/64

SCHEMATIC DIAGRAM
MODEL
C612AL

ELECTRONIC MEASUREMENTS COMPANY, INCORPORATED (KINGSTON, NEW JERSEY)	
DWG. NO.	349D77
SIZE	11
SHEET	1 OF 1 SHEETS

MP MASTER



MA27878